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CIVIL ENGINEERING.

On the Construction of Wrought Iron Lattice Girders.

By THOMAS CARGILL, C. E.

From the Lond. Civ. Eng. and Arch. Journal, Oct., 1862.

THE many and peculiar advantages possessed in general by wrought iron bridges of every description, in the facility with which they can be rendered available in situations were similar structures of masonary could only be erected at a far greater cost, attended with much risk and uncertainty, are daily rendering them more important objects of study and attention to the professional man.

It is true, that these advantages may be also claimed by cast iron girders, but they lack one indispensable requisite—namely portability, for a cast iron girder must arrive at its destination in as sound and perfect condition as when it left the workshop, and this is rather a hazardous matter to accomplish, when we take into consideration the chances of injury which may accrue to it during its transit from one country to another; the difficulty of transporting the castings safely increases with their size and weight, which depend, *cæteris paribus*, on the span of the bridge.

It is widely different with respect to a wrought iron girder, the component parts of which can be separated, respectively packed together, and despatched over land or sea to the future site of their erection, with very little fear of accidental injury; moreover, in the event of any occurring, the nature of the material and the size and form of the

different portions would more readily admit of repair than in the former case.

I am aware that large castings have been sent from this country, and reached their destination in perfect safety; but that the preference is given to wrought iron (with the exception of the system introduced by Col. Kennedy) as the material for railway bridges intended for foreign countries, is amply manifested by its very extensive use in the iron bridges and viaducts of our Indian Railways, all of which I believe were, and continue to be, manufactured in England. The viaducts over the Soane, Jumna, and other large rivers, furnish magnificent examples of its utility, and of the engineering skill displayed in its application.

There are however far weightier considerations, such as the failure of several cast iron bridges, together with the treacherous and uncertain nature of the material, which altogether preclude any comparison between cast and wrought iron bridges, except in the case of very limited spans. The latter cause for non-reliance on such a substance has, unfortunately, been but too well evidenced by the New Hartley Colliery accident, which cost us the lives of over two hundred of our mining population. It may not be out of place here, in illustration of the difficulty experienced in transporting large and heavy castings to even a comparatively short distance, to quote from the Report of Mr. W. Tierney Clark respecting the proposed bridge to connect Buda with Pesth, across the Danube, in Hungary. Mr. Clark in his report alleges, on the supposition that the bridge was to consist of cast iron arches, that "it would be next to impracticable" to obtain the safe transport of the necessary castings from England.

The different forms in which wrought iron girders have been constructed are exceedingly numerous, but all those which experience has shown to be adapted and safe for railway traffic may be classed under the following heads:—1, all girders having continuous webs, such as the plate, tubular, box, &c.; 2, those having open webs, including the trellis, lattice, triangular, &c.; 3, the arch; 4, the bow and string—under which denomination the late Mr. Brunell's stupendous Royal Albert Bridge might come, although in reality it embodies a variety of principles in its construction.

I exclude from this enumeration all bridges purely on the suspension principle, hanging girders, and others of a similar description, which have not yet been sufficiently tested in practice to warrant their being included under the head of Railway Bridges. Some might think that the Niagara Suspension Bridge should be made an exception to the above, but when we consider that railway trains are not permitted to cross it at a greater speed then five miles an hour, it can hardly be called in the proper sense of the term a railway bridge—at any rate, not in this country; for it is certain that no Government Inspector would pass a line as fit for public traffic, over a portion of which it would be always unsafe for a train to travel at a greater velocity than five miles per hour. Wrought iron lattice girders have been gradually gaining ground with the profession, since the erection of the Boyne

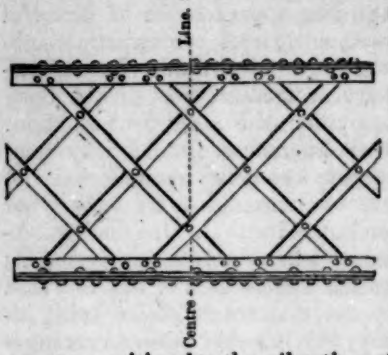
Viaduct, one of the largest, if not the largest example of the kind, taking the span as our datum. It is true that the Commissioners appointed in 1848 to inquire into the Application of Iron to Railway Structures reported that "lattice girders appear to be of doubtful merit," but now we might safely, without fear of contradiction, substitute the term "undoubted" for the word "doubtful." Lattice girders, trellis, triangular, and the different modifications of the open web form, have been often included under the same denomination. Without going into all their respective differences, I will briefly mention as sufficient for my present purpose the chief characteristics of the lattice girder proper, which serve to distinguish it from the other forms which have been sometimes confounded with it. One distinguishing feature is, that all the compression bars or struts, composing its web are inclined at the same angle as the tension bars or ties, and that it does not admit of vertical struts; any that are so placed being intended to act merely as stiffening bars; this is a very common arrangement with single lattice girders, and is indispensably requisite when they have any considerable depth. Again, the connexions of the different parts are all made by the use of rivets, and never by the employment of pins, as is the case in Warrens' triangular girders. There must also be, at least, one crossing of the diagonals in the web to constitute a lattice girder; this occurs in the very smallest examples, namely, those which are used for the cross girders of large bridges. Lattice girders may be either single or double; the former require so very large an amount of bracing to keep them steady, that they have been greatly superseded by the latter form; they are however, when of limited dimensions, exceedingly well adapted for cross girders and accommodation under bridges, &c.

Fig. 1, which is drawn to a scale of $\frac{1}{3^{\prime}6}$, is the elevation of a central portion of a wrought iron double lattice girder, showing the plates, angle iron, tension and compression bars, and connecting rivets. The girder may be divided into three principal parts, viz: the top and bottom flanches, and the intermediate portion attached to them. In the following investigation I shall use the word "flanches" to denote the collective area of the plates and angle irons at the top and bottom of the girder; while the tension and compression bars, or ties and struts, forming the intermediate portion, will be included in the term "web" (for a further explanation of these terms, the reader is referred to Mr. Latham's excellent work on Wrought Iron Bridges.) The compression bars are, generally speaking, those which slope away from the centre of the girder towards the ends; and the tension bars those which slope in the reverse direction. Sometimes a careful calculation is necessary to decide whether a bar is in tension or compression, as a bar may be acted upon by both tensile and compressive strains at the same time; but a bar is correctly said to be in tension or compression, according as one or other of these strains preponderate.

In Fig. 1, the web is shown attached to the angle irons by rivets; at a certain distance from the centre they increase gradually toward the ends of the girder, according to the scantling of the ties and struts,

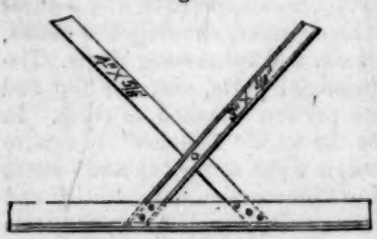
which vary similarly in the same directions; the strains upon the rivets of any one strut and upon those of its corresponding tie are by no means equal, as might at first be supposed; for, if the ends of the struts be cut to the proper angle and abut fairly against the upper and lower plates, the rivets are relieved of some portion of the strain which would otherwise fall on them; if the struts were perpendicular to the flanches, that is, if we made uprights of them, so that the pressure should be in a vertical direction, there would be very little need of rivets, except to keep them from being shifted from their proper position by the vibration of the girder under a load, the tendency of which is to destroy the equilibrium of the structure by altering in the normal directions of the lines of pressure. It is otherwise with the bars in tension, as in their case the rivets have to bear the whole of the direct pull, or longitudinal strains which pass along the bar, and transmit them to the angle irons.

Fig. 1.



Towards the ends of the girders, where, in consequence of the increased amount of strain brought upon the web, the ties and struts are of larger scantlings than at the centre, it would be more advantageous, instead of inserting the rivets, as is frequently done, along the line of the longitudinal axis of the bars, to place them in the manner shown in the tie bar, Fig. 2; this evidently cannot be done with the channel iron strut shown in the same figure, and it may be remarked, that the principle disadvantage of this form of iron, otherwise so well suited for compression bars, is, that more than one rivet cannot be inserted in the breadth of the channel portion of the sections usually manufactured. It will be seen, on referring to the figure, that the latter method distributes any strain, which is induced in the bar through the medium of the rivets, much better than the former, for when they are all placed in the centre line of the bar the direct strain also passes along that line, or, so to speak, along the central longitudinal fibre; when placed as in the example before us, they distribute the strain along three parallel fibres in lieu of one, and it needs no explanation to show, that where it possible to attach each individual fibre of the bar separately to the angle irons, the maximum distribution of the strain along the bar would then be obtained. Judging solely from this statement, combined with the well known fact that small bars and

Fig. 2.



Scale 1·36.

plates are proportionally stronger than the others of the same length but of greater sectional area, it might be inferred, that the most judicious arrangement in a lattice girder would be to have a large number of bars of small dimensions; the extent to which it might be advisable to carry out this in practice will be limited by the consideration, that the closer we bring our bars together within a certain distance, the more we encroach upon the properties belonging to girders having continuous webs. Into a comparison of the relative merits of the two kinds of structures, it is not my intention at present to enter. The best example of the practical application of the above principle is to be found, as far as my own knowledge goes, in the strands of the cables of the Niagara suspension bridge; these strands are composed of wires so small, that it requires sixty of them to make up one square inch of section; making use of mathematical language, and putting $\pi d^2 = .^1_{60}$, we obtain the thickness of the wire equal to about 0·146 of an inch.

We will now pass on to investigate the manner in which the longitudinal angle irons perform the duties imposed upon them. Their chief office is to attach the webs to the plates, they should also distribute the strains uniformly over the plates as much as possible; and, moreover are intended to act as stiffeners to the flanches; this last duty they perform principally by the trough-like form they impart to them; it would thus appear advisable to employ unequal-sided longitudinal angle irons, with the longer side vertical, which would also afford more bearing for the webs; but, on the other hand, it is well to have all the material used in calculating the strength of the flanches as close together as can be conveniently done, and there is no advantage to be gained in giving the bars more hold than is necessary, on the contrary, there would be a loss of metal without any adequate compensation for it.

In order that the angle irons may connect the plates and web together, they must themselves be riveted to the plates first; and here occurs a serious disadvantage inseparable from their use, for, to obtain this connexion, a certain amount of metal must be punched or drilled—the latter is preferable for many reasons—out of the top and bottom plates, which are therefore weakened, although not equally so, in proportion to the size and number of rivets employed for the purpose.

This will be at once understood by a reference to Figs. 3 and 4, which represent a portion of the plan of the inside and outside of the plates shown in elevation in Fig. 1. The rivets are their shown 6 inches apart from centre to centre breaking joint, or, as it might be termed, with an alternate pitch of 3 ins. Instead of disposing the rivets in this manner, it is a very common practice to place them all in the same line across the plate, so that the line of fracture, or direction along which the plate would have the greatest tendency to split, would be through the rivets 1, 3, 4, 6, instead of through 1, 2, 4, 5; and it is alleged in defence that the plate would be as likely to split through the latter as the former direction. When the rivets have a pitch of only 3 or 4 inches, this statement becomes practically true, for then the net sec-

tion (by which I mean the section of material left to resist fracture after deducting for rivet holes) along these two different directions is so very nearly equal that it is a matter of indifference whether they break joint or not; in the whole I consider it preferable in any case not to insert the rivets in the same line, partly because there must always be a slight increase of section obtained by causing them to break joint, varying directly as the pitch, and also they distribute more efficiently the strain which is brought upon the plates by the angle irons. I may state here that it is not my purpose to give a design for any particular bridge, but simply to make use of such portions of a design as may serve to illustrate the present remarks. The dimensions of the various parts in the figures originally answered for a girder of 60 feet span for a single line of rails. In order to show clearly

Fig. 3.

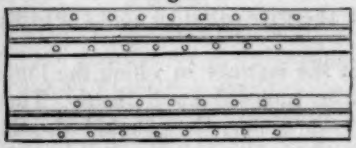
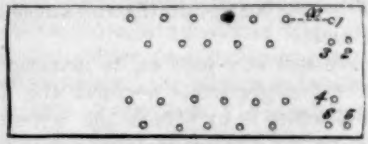


Fig. 4.



Scale 1·36.

the comparison between these two methods of disposing the rivets in the plates, we will take an example. Let b be the breadth of the plate; n the number of rivets along the line of fracture, or the line through which the net section is calculated; d the diameter of the rivets, and t the thickness of the plate; let x also = the distance from the edge of the plate to the centre of the first row of rivets, and p the pitch of the rivets. Putting L and L_1 for our two lines of fracture, and S and S_1 for the corresponding net sections, we obtain, when the line of fracture lies through the rivets, 1, 3, 4, 6, (see Fig. 4,)

$$L = (b - nd)\,; \quad S = Lt = (b - nd)\,t\,;$$

when the line lies through rivets 1, 2, 4, 5, as in the case of the rivets breaking joint,

$$L_1 = 2x + \sqrt{\left\{ (b - 2x)^2 + \frac{3p^2}{4} \right\}} - nd$$

$$\text{and } S_1 = L_1 t = \left\{ 2x + \sqrt{\left((b - 2x)^2 + \frac{3p^2}{4} \right)} - nd \right\} t.$$

Now making $b = 24''$, $n = 4$, $d = \frac{3}{4}''$, and $t = \frac{1}{2}''$, we have $S = 10{\cdot}5$ square inches; using the same notation in our second example, with the addition of $x = 1\frac{1}{2}''$ and $p = 8''$, which is about as far apart as would be desirable to place the rivets in this instance, we obtain $S_1 = 11{\cdot}05$; as x, although not introduced in the first equation, is common to both, insomuch as it forms a portion of the total breadth b, it follows that the difference between the two sections is as the pitch of the rivets. With respect to the disposition of the rivets in a longitudinal direction, the nature of the construction leaves us very little choice; the position of the angle irons determines that of the rivets; the first angle iron is usually placed as shown in Fig. 3, with the edge

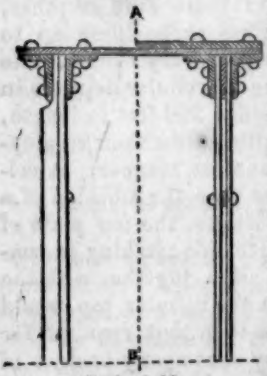
of the horizontal side flush with the edge of the plate, the space between it, and the one closely adjoining it, is fixed by the maximum thickness of the web to be inserted between them, as will be mentioned hereafter; the other couple are similarly placed, and the rivets run along the centre of each. It results from adjusting the angle irons in this manner that there is a much wider space between the two rows of rivets nearest the centre of the plates than between them and the outer rows, and the consequence is that the bearing is confined more or less to the edges of the plates instead of throwing the strain well into the central portion of the flanches; this could be obviated, and the distances between the rows of rivets more equalized by shifting all the angle irons nearer the centre of the plate, still retaining the same space between each couple; but, by doing so, we also bring the webs nearer each other, and thus virtually destroy the very principle of the double lattice girder, which is to keep the webs as far apart as the breadth of the top and bottom plates will permit, in order to obtain that degree of lateral stiffness which a single lattice girder never affords; for it is certain, that in nine cases out of ten, a single lattice girder would fail throught the distortion of its web long before its ultimate strength could be rendered available. Suppose that we continue to move the angle irons, in pairs, until they are in contact, then the webs will also touch one another, and the structure becomes changed from a girder of the former to one of the latter description.

In all double lattice girders I am strongly inclined to doubt whether the full strength of the plates is ever called into play, except in the joints, where the riveting is continued right across the plate, by the method employed of riveting the plates and angle irons together in a longitudinal direction; and where the plates exceed 2 feet in breadth. I think the whole value of the material is not obtained without the aid of occasional transverse stiffening pieces of some kind or other, which would also tend to prevent the crippling or buckling up to which the plates are always liable. In girders of very considerable length, this object is accomplished by the use of cellular tops, as in the Menai bridge, but unless the girder exceeded 200 feet in length, it is questionable whether the advantages resulting from their employment could not be economically obtained in another manner. A cellular top applied to any girder is nothing more than the addition of a small three-sided box girder along its whole length, the top plate of the main girder supplying the place of the fourth side; taking in consideration the number of joints in its top and sides, together with the numerous stiffening pieces, we shall find that the cellular top would demand an amount of workmanship little less than that required for the main girder; moreover, unless when they accompany bridges of very large spans, they are of dimensions so limited that there is no getting at their interior when they are once put together and placed in their proper position. The observations made above respecting the central portion of the plates of the lattice girder not being called into play, also apply to the cellular top, but not so forcibly, as there are usually internal bracings or diaphragms constructed at certain dis-

tances, which cause a more equal and uniform distribution of the strains.

To return to the double lattice, the manner in which the connecting angle irons tend to stiffen the flanches is at once seen on inspection of Fig. 5, which represents two half-vertical sections; that to the right of the line A B is taken through the centre of the girder where the ties and struts are both plain bars; the other section is made near to the end, where the struts are usually formed of either angle, T, or channel iron; in the figure channel is the form shown, and the thickness of the web at that point is a maximum, which, as I have before stated, regulates the distance at which the pairs of angle irons are to be placed from one another. As the thickness of the web is continually varying, it becomes necessary, wherever it falls short of the maximum, to insert filling or packing pieces between the bars, to compensate for the deficiency, and to insure the angle irons being retained at a uniform distance apart; the packing pieces are shown in the section to the left of the line A B, Fig. 5. To avoid confusion in this respect I have shown the web as altogether in elevation, although it is evident on looking at Fig. 1, that a vertical section through it would cut the bars in one or more places, which crossings are omitted in the section for the above reason. If we call d the maximum thickness of the web, or, what is the same thing, the distance between the couple angle irons, and if t be the thickness of the web at any point then putting p for the thickness of the packing piece required, $p=(d-t)$: this equation will however only hold good were the construction is similar to that represented in Fig. 5. At first sight, the weight of the packing pieces would not appear to be of much consequence, any one would be ready to put them in, here and there, wherever they might be required, without considering whether they might be dispensed with or not; in taking out the quantities of a double lattice girder of the moderate span of 80 feet, I have found the weight of the filling pieces to amount to a considerable item. Also, as the packing pieces cannot be included in obtaining the area of the flanches, in the calculation respecting the strength of the girder, they merely add to its weight without increasing the strength. When channel iron is employed for the compression bars there are three different ways of attaching them to the flanches. In Fig. 5, the strut is shown riveted between the double angle irons, and to effect this a small portion of the webs are cut off at each end, which allows the channel part to be inserted, but at the same time it somewhat weakens the strut; this may be avoided when thought necessary, by placing the strut outside one of the angle irons, and thus getting the full net value of the metal; this advantage, however, is gained at the expense of the far better hold which is afforded by the insertion of the struts between

Fig. 5.



Scale 1·18.

the angle irons, and it also makes the distance between the double angle irons so small, that it might be preferable to use T-iron, instead of pairs of angle irons when this method is adopted, and thus reduce the number of filling pieces to those required at the crossings only of the ties and struts. The arrangement represented in Fig. 5 may be adhered to without depriving the compression bar of any of its strength, for instead of cutting off the ends of the webs, they may be bent over and forged down upon the channel part, thus increasing its thickness, but at the same time it would increase the distance between the double angle irons, and so necessitate an addition to the thickness of every filling piece employed.

If T or angle iron is used, instead of channel for the struts, there must still be some cutting off or forging of the ribs, in order to make them fit in between the angle irons. The manner of attaching the tension bars is too simple to require any remark. The opposite lattices in the same girder are very often joined together by either a piece of bar or angle iron running from one crossing to another, and in large girders the opposite compression bars are united throughout their whole length by diagonal bars; in the latter case T or angle iron would be better sections than channel, as, unless the compression bars are of very heavy scantling, the webs of the channel iron would be very unfavorable for the insertion of rivets.

Having now considered the main features in the construction of wrought iron double lattice girders of moderate span, I will endeavor to point out in what manner I think some of the defects may be remedied, without losing any of the advantages possessed by the present methods in use.

(To be continued.)

Prevention of Decay in Timber for Shipbuilding and other Purposes.

From the Journal of the Society of Arts, No. 519.

An essay on the subject of Decay in Timber, and its prevention by a new system of carbonization, has been recently published by M. de Lapparent, Inspector General of Timber for the French Navy, and it is stated that the method of preservation therein described is extensively adopted at the present moment in the French Government dockyards for their line-of-battle ships, as well as by railway companies both in that country and Spain, for the preservation of their sleepers, &c. It has been thought that a translation of portions of this work would be interesting to the readers of the *Journal:*—

It is stated in the preface that it is a fact established by the agricultural statistics of France, that the annual consumption of timber in that country considerably exceeds the re-production, and, by the continued impoverishment of the land in that particular, not only are the interests of the agricultural and industrial population immediately affected, but their future requirements compromised and endangered.

Very few persons have even an approximate idea of the enormous consumption of timber which takes place annually in France. It is

generally believed that the shipbuilders are the principal consumers, and this would be true to a certain extent if it only related to timber of extraordinary or unusual dimensions; but as regards quantity, the consumption for shipping is almost insignificant, as evidenced by the summary of statistics given below, collected by an inspector of forests attached to the Central administration.

Statistical Summary of the Annual Consumption of Timber in France.

	Cubic Metres.		Cubic Feet.
Naval and Merchant service,	80,000	or	2,825,328
Artillery and Engineers do.	30,000	"	1,059,498
Railways,	200,000	"	7,063,320
Buildings,	1,600,000	"	56,506,560
Cooperage,	1,600,000	"	56,506,560
Vine props,	2,000,000	"	70,633,200

This statement does not comprise timber imported from abroad. It is at the outside a minimum; first, because it estimates, at much too low a figure, the consumption by the railways; and secondly, because it does not take into account the timber used in mines for propping up the galleries; in the building and repair of canal and river boats; in the hop-grounds; in wheelwrights' work; and in the manufacture of furniture, &c. Mons. Burat, Professor of Commercial Statistics, of the Institution of Arts and Sciences, does not hesitate to estimate the annual consumption of timber in France, in building and manufactures, at 10,000,000 cubic metres, or 353,166,000 cubic feet, to which must be added 30,000,000 cubic metres, or 1,059,498,000 cubic feet for fire-wood, and 15,000,000 cubic metres, or 529,749,000 cubic feet made into charcoal.

Now the produce of the timber sales, under the management of the Inspector of Forests, varies between 70 and 80 millions of francs, or £2,800,000 and £3,200,000 each year. Allowing, therefore, that the private forests, the area of which is equivalent to the whole of the government forests,* produce the same sum, the maximum amount arrived at is only 160,000,000 francs, or £6,400,000.

This amount in fixing the average price of the cubic metre (or $\frac{3}{10}$ cubic foot) of timber for building and other purposes at 30 francs (24s.) only, will be more than absorbed by this calculation. The forests, therefore, will be absolutely inadequate to meet the enormous consumption abovementioned, if the clearings (which on an immense scale are continually taking place) and the scattered timber which marks the division of properties are not taken into account.

Unfortunately the landholders are foolishly advised, and object to having timber round their fields; neither will they replace the trees

*The area of the forest in France, at the period of the conquest of the Gauls by Julius Cæsar, is estimated at 40,000,000 hectares, or—

	Hectares.		Acres.
Royal Forests,	1,100,000	or	2,720,900
Forests belonging to the Communes and Public Institutions,	1,900,000	"	4,699,840
Private Forests,	3,500,000	"	8,657,600

so that the State, which ought to be the sole proprietor, is now the owner of the smallest portion of forest land.

they cut down, while the gradual diminution of individual wealth is constantly urging on the conversion of the forests into cultivated land. The consequence is, that in proportion as the consumption increases, the supply diminishes; the value is thereby augmented, and the wish to realize quickly adds to the impoverishment, of which the disastrous effects are already felt in many parts of France. It is therefore of great importance to discover a method of prolonging the durability of timber for building purposes, and, by diminishing the consumption, to arrest this scarcity.

The author states his opinion that the rapid decay of modern-built ships is traceable to this cause alone—that we cannot leave them sufficiently long on the stocks to be seasoned. Such also will be the fate of the magnificent cuirassed frigates, if some efficacious remedy be not speedily applied. The risk is even so much the more to be dreaded for the new ships, as the casing of the upper part of the broadside with the iron plates must have the effect of increasing considerably the inertia of the sides; and the variations of her draft during stormy weather will be much greater, when, by reason of the decay of the ribs, the bolting which fastens the planks to the timbers will no longer have sufficient hold.

The following points may be considered separately:—

1. The selection and employment of timber, with regard to its natural qualities.

2. The preservation of store or yard timber, and its preliminary artificial seasoning for building purposes.

3. The precautions to be taken in ship or other building, and the preparations to be applied to timber, either to neutralize the agents of decay, or to render it impervious to them.

1. *The Selection and Employment of Timber.*—After some remarks upon the oak grown in France, and the mode of selecting the best qualities, the author goes on to say:—

With regard to foreign timber, that grown in Italy and on the shores of the Adriatic is the best that can be used for the ribs of ships, and should be carefully sought for. For planking, ceiling, and longitudinal joining, Indian teak (as famous for its durability as for its specific lightness and toughness) should be selected. An opportunity will also soon occur of largely extending the working of the immense timber forests in Guyana, of which certain species of timber, from some experiments made by the author, give promise of qualities altogether unexceptionable—such as elasticity, strength, and durability.

In Guyana the forest trees do not grow in clusters, like the oak and beech in France; on the contrary, several species, without order or any relative analogy, are mingled together, so that, for any good to be done, it would be absolutely necessary to select a certain number of species. Fortunately, those which are met with in the greatest abundance, are also those which offer the greatest resources for shipbuilding—such as the Angélique, the Coupi, the Violet tree, and the Wacapoa.

TABLE.

	Weight of the Cube Metre (35½ cub. feet).	Amount of pressure.		Elasticity.			Appearance of Fracture.	Co-efficients.	
		At yielding point.	At point of fracture.	Under a pressure of 220·10.	Extent of Elasticity.	At commencement of Fracture.		Of Elasticity.	Of Fracture
	lbs.	lbs.	lbs.	Feet.	Feet.	Feet.			lbs.
Forest Oak (French),	1644	276	331	0,7874	0,13778	0,21249	short.	62,500	124
Moulmein Teak (superior),	1435	441	634	0,03937	0,10236	0,14566	in splinters.	125,000	238
Moulmein " (soft),	1302	386	441	0,07086	0,14960	0,17715	short.	69,500	168
Guyana Timber. Angélique,	1700	508	607	0,03543	0,11417	0,13778	splinters.	140,000	225
Coupi,	2207	500	551	0,04724	0,14173	0,19291	"	104,000	207
Violet-wood,	1865	717	883	0,03543	0,13779	0,27559	"	140,000	331
Wacapoa,	1858	607	662	0,03937	0,15768	0,19685	"	125,000	248
Balata,	2362	828	1048	0,02362	0,13779	0,27559	"	207,500	370
Courbaril,	2075	772	938	0,01967	0,14960	0,23632	"	250,000	351
Taoub (yellow),	1910	551	662	0,03543	0,14172	0,35433	"	140,000	248
Saint Martin,	2053	717	772	0,03543	0,14172	0,17322	"	140,000	289
Black Cedar,	1766	607	662	0,04330	0,13385	0,18716	"	114,000	289
Beech (injected with sulphate of copper),	1744	331	386	0,05511	0,14172	0,28346	short.	89,000	136,10
Poplar (injected with sulphate of copper),	86010	22010	276	0,12204	0,12204	0,26622	splinters.	41,500	103,3

From the specimens procured by the author, he cut a certain number of lengths of wood about 20 millimetres (or three-quarters of an inch) thick, which, by the machine used at Cherbourg for experiments of this kind, have been tested with other lengths cut from planks of forest oak taken from the stores of the same port, and with another length of Moulmein teak brought from England to line the broadside of the *Normandie* frigate under her iron plates. He added to these some lengths from a sample of Indian teak of superior quality; also lengths of beech and poplar, which had been injected with sulphate of copper.

The Table (p. 14) is the average results of the first series of experiments, in which three lengths of each species were subjected to the machine or steelyard; all had been cut for some time, and appeared equally seasoned; the space between the points of support was 20 centimetres, or about eight inches. An apparatus made for the purpose enabled him to calculate the elasticity almost to the tenth of a millimetre.

From the preceding table it is evident that if we represent by an unit either the comparative elasticity of the oak, or its power of resistance to fracture, we shall have the following series of proportionate numbers corresponding to the other species:—

Description of Timber.		Proportionate Numbers.	
Forest Oak,		1000	1000
Teak (superior),		2000	1920
Teak (soft),		1100	1330
Guyana Timber,	Angélique,	2250	1830
	Coupi,	1760	1660
	Violet-wood,	2250	2650
	Wacapoa,	2000	2000
	Balata,	3325	3150
	Courbaril,	4000	2825
	Taoub (yellow),	2000	2000
	Saint Martin,	2000	2325
	Black Cedar,	1820	2325
Beech (injected with sulpate of copper),		1420	1100
Poplar, " " "		0655	0830

Without wishing to attach any specific importance to these experiments, which require to be repeated and varied, the relative inferiority of the soft oak of French forests, as regards elasticity and power of resistance to fracture, cannot but be remarked. It will also be observed how unsatisfactory was the teak brought from England for the lining of the iron-plated frigate. It appears that the forests of Moulmein are exhausted, and in that locality we can only find timber of a mediocre quality. The author's opinion is, that we must now go to the shores of the Bangkock, in the kingdom of Siam, where immense forests, yet unexplored, are to be found. The high numbers to which the several species of Guyana timber refer are well worthy of attention, as well as the identity which appears to exist between

the Angélique and the Moulmein teak of superior quality, which justifies the distinctive appellation sometimes given to the Angélique as "the Guyana teak."

But whatever may be the importance attributed to the qualities of elasticity and strength, there is one which, in shipbuilding, ought to take precedence of all the others, and that is durability. It is true that in general (and experience has shown that this rule applies strictly to the oak) the strongest and most tenacious timber is at the same time the most durable; but when there is a question of the other species, the rule does not always prove correct, so that to form a true and just opinion of the quality of timber, it is necessary by direct experiments, to estimate its relative durability. The author gives the details of those made by himself. Taking a new set of lengths chosen from the same specimens of timber, he put part of them in a box with alternate layers of moist horse dung, and the box was then hermetically closed. The other lengths were driven into damp earth, a little more than half their depth. After remaining six months in these positions, the several lengths were withdrawn and subjected to the steelyard. Some of them had lost more in the dung, and with the others the contrary was the result.

The average of the two losses is recorded in the following table.

It is impossible not to be struck with the astonishing superiority in every point of the several species of timber from Guyana.

The Angélique especially appears destined to render the greatest service to shipbuilding, for in addition to its qualities of elasticity, strength, and durability, its density does not exceed that of the common oak. On the contrary, the other species are a little heavy, without however being excessive in that respect. Their place will be at the bottom of the ship, while the Angélique will be advantageously substituted for teak on the broadside under the iron plates.

TABLE OF COMBINED LOSS OF STRENGTH OF DIFFERENT SPECIES OF TIMBER, AFTER REMAINING SIX MONTHS IN THE EARTH OR DUNG.

DESCRIPTION OF TIMBER,		Loss per Cent.
Forest Oak,		30
Teak (superior),		15½
Teak (soft),		25
Guyana Timber,	Angélique,	5
	Coupi,	0
	Violet-wood,	0
	Wacapoa,	0
	Balata,	10
	Courbaril,	12½
	Taoub (yellow),	31⅓
	Saint Martin,	14⅓
	Black Cedar,	22½
Beech (injected with sulphate of copper),		30
Poplar, " " "		10

(To be Continued.)

MECHANICS, PHYSICS, AND CHEMISTRY.

Notes on the Introduction of Steam Navigation. Read by Mr. DYER before the Manchester Literary and Philosophical Society at the ordinary meeting, Feb. 10, 1863.

From the Lond. Mechanics' Magazine, February, 1863.

Mr. Dyer stated that this subject, being of great importance, had engaged many able pens in tracing the origin of the several inventions and experiments that preceded the final triumph of steam power over that of wind for navigating ships; each writer claiming the honor of priority for his own country. It may be useful to state the order in which and the parties by whom the principal attempts were made to realize that object. Several letters lately appeared in the *Times*, and were thence transferred to the pages of the *Engineer*, giving a graphic account of the "first steamer in English waters," the *Margery*, built at Dumbarton, by the late William Denny, for William Anderson, of Glasgow, and passed through the canal to the Forth, and thence to the Thames, where she arrived on the 23d of January, 1815. On the authority of Mr. Anderson, then, this date is fixed when the first steamboat was seen in English waters. The first steamboat, the *Claremont*, was started as a regular packet on the Hudson river in the spring of 1807; so that the first steamer seen on the American waters was fifty-five years ago, a lapse of time that should now insure a calm view of the steps that led to this first actual success in steam navigation. It will be shown that by a long course of persevering labor, the honors of that success must be conceded to Robert Fulton, by whom it was achieved.

Whilst admitting the merits of other ingenious men long engaged in the same pursuit, it is clearly proved that, either from good fortune, or by the exercise of superior judgment and skill, the race was won by eight years priority of steam navigation, by Fulton, on the Hudson river.

In 1793, Mr. Fulton sent his plan for a steamboat to Lord Stanhope, who approved of, and thanked him for the communication. Shortly after, Fulton went to Paris, and made experiments on the French waters, with the chain floats, the duck's-foot paddles, the screw or smoke-jack propellers, and with paddle wheels, to which latter he gave the preference, and constructed a boat with them in 1803, which was the model adopted in building the *Claremont*, in 1806.

Mr. Dyer had sailed in the *Claremont*, and remembers the sensation created by her appearance, and the high admiration bestowed on the author of so great an enterprise. That sensation in 1807 was precisely the same as the *Margery* created among the vessels on the Thames in 1815.

All attempts at steam navigation were fruitless before the invention of Mr. Watt's steam engine, his engine being the first that could be usefully applied to rotative machines on land, and therefore for pro-

pelling ships. The principal claims put forth by other inventors of steamboats are the following:—

In France, the Marquis de Jauffroy constructed a steamboat at Lyons, in 1782, "with paddle wheels," but that this boat did not succeed is obvious, because she was not heard of until 1816, when the first Fulton boat was started to run on the Seine.

In 1783, Daniel Bernoulli proposed a plan which consisted of forcing water through a tube, out at the stern of the boat. This scheme has been tried many times since, but fails on account of the defective principle of applying the force. Endless chains with float propellers, have been many times tried, and have failed on the same ground.

In 1795, Lord Stanhope made experiments with a boat on the Thames, using the reciprocating or "duck's-foot paddles," which also failed from the loss of time and power by the return stroke.

In 1785, James Rumsey, of Virginia, tried a boat on the Potomac, and afterwards in London, both without success; and about the same time Mr. Fitch, of Philadelphia, tried one with paddle wheels on the Delaware, but this boat also did not succeed and was given up as a failure. J. C. Stephens of New York, made experiments in 1804, with a "boat 25 ft. long and 5 ft. wide," which of course did no good, and was stopped as a failure, though again brought to notice as preceding Mr. Fulton's.

In 1788 and 1789, William Symington, in conjunction with Patrick Miller and James Taylor, made experiments with their patents for navigating by steam, and in 1802 commenced running a boat on the canal at Glasgow, which made three miles an hour, but after many changes of her propellers and trials, the scheme was given up, and no more was heard of the steamboat of Mr. Symington until long after those of Fulton were widely spread over the American waters.

In 1816, the Marquis De Jauffroy complained that the Fulton steamboat on the Seine had taken the "paddle wheels" invented by him and used at Lyons thirty-four years before, but also abandoned by him. To this charge Mons. Royou replied in the *Journal des Debats*, thus:—"It is not concerning an invention, but the means of applying a power already known. Fulton never pretended to be an inventor in regard to steamboats in any other sense. The application of steam to navigation had been thought of by all artists, but the means of applying it were wanting, and Fulton furnished them."

The first ocean steamer was the *Fulton*, of 327 tons, built in 1813, and the first steamer for harbor defence was built under Fulton's direction, 2740 tons, launched in 1814. This became the model ship for the iron clad batteries and rams since constructed with many changes. It will be seen by the drawings of Fulton's plans, that he had tried the several other kinds of propellers—the chain float, duck's-foot, and the screw fan—before adopting the paddle wheel, for though the screw was good in principle, it was many years before it could be constructed to act efficiently. The *James Watt* was the first boat with the screw running between London and Havre, about ten years after the advent of the *Margery*.

In 1811 I endeavored to introduce steam navigation into England, but I found a strong conviction that it would not answer in this country, our most eminent engineers saying, "We don't doubt the success of steamboats in the wide rivers and harbors of America, but in our comparatively small rivers and crowded harbors they will never answer." Even such scientific engineers as the late John Rennie, Sen., and Peter Ewart, a vice president of this society, both advised me to relinquish the attempt to introduce steamboats, as sure to prove a waste of time and money to no purpose. However, when conviction came over the public mind that steam navigation would answer here—but not until after more than 5000 tons of steamboats had been launched on the Hudson in 1816, did it so come—then began the spread of steam navigation, since extended with such marvellous rapidity and perfection as to atone for the sluggish beginning. Since nations are indebted to the genius of Watt for success in using steam power, to that of Fulton for its successful application to navigation, to Stephenson for the like success on railways, the meed of praise due to each of their names should be cheerfully awarded by all who are so largely benefited by the result of their labors. In doing this we should bear in mind, that inventions do not spring into existence perfect from their birth, like Pallas from the brain of Jupiter, but they come from the prior labors of many brains, and he is the true inventor who first collects the essence of and gives the stamp of vitality to those labors. In this sense the invention of steam navigation will forever illustrate the name of Robert Fulton.

Sucking and Blowing the Mail.

From the London Mechanic's Magazine, January, 1863.

Just two hundred and eight years have elapsed since the then Burgomaster of Magdeburgh, Otto von Guericke, invented the air-pump, and astonished the Emperor of Germany at Regensburgh, by exhibiting the apparatus in action. By means of his contrivance he exhausted a tube wherein a piston was fitted and made to slide easily, and thus raised a heavy weight to a considerable height. Since the time of the ingenious and scientific Burgomaster—who, it is some satisfaction to say, had previously been a student at Oxford University—many efforts have been made to employ atmospheric pressure in the performance of mechanical and industrial operations. These efforts have, for the most part, proved failures, commercially or practically, and we really have not succeeded to any extent as yet, in pressing the atmosphere into active service. Everybody remembers the various railway schemes on the atmospheric principle which, from time to time, have occupied the attention of our cleverest mechanics, and all know that they have been abandoned. Mr. Brunel tried the system in South Devon until the patience of the shareholders with whom he had to deal was exhausted more completely than the propelling tubes of the railway ever was by the application of his gigantic pumps, and then the whole of his costly apparatus was sold as old iron. The Kings-

town-Dalkey atmospheric line maintained its ground longer than any other, but it at last yielded to the Locomotive, and has ceased to exist. These are certainly far from being encouraging facts, but they assuredly will not deter other inventors—worthy disciples of Otto von Guericke—from perseverance in the same direction. For their comfort, it may be mentioned, that in one remarkable instance, at least, atmospheric pressure has been made subservient to mechanical art, and is employed efficiently and economically. The coinage of the British empire is stamped entirely by its force. We have not space nor time at present to enter into a description of the beautiful arrangement of air-pumps, vacuum chambers, levers, springs, and valves, by means of which impressions are given at the Mint, with rapidity and precision, to the coins which issue from that establishment. It must suffice to say that the air we breathe literally coins the money we use, and that therefore there is yet hope for atmospheric engineers. It is now proposed to make the atmosphere our General Postman, as well as our Chief Coiner, and we cannot see any practical obstacle to its becoming so. The only doubtful point—and it is one which actual experiment can alone solve—is the commercial one. That atmospheric pressure may be made to transfer letters and parcels by wholesale from the Land's End to John o' Groats is a certainty. That its employment, in lieu of other modes of transit, will effect advantages in a pecuniary sense, is another question. The Pneumatic Despatch Company, which has now been in existence some two years, answers the important query affirmatively; and on a comparatively small scale they are essaying to demonstrate the truth of their views.

On a piece of waste ground, the property of the North-Western Railway Company, and to the right of the carriage entrance of the Euston station, the would-be atmospheric letter-carriers have erected their first pneumatic apparatus. An engine-house—for steam is the prime mover after all—has been built on the spot named, and this shelters an engine of some 20-horse power, with boiler and appurtenances, together with a gigantic disc of some 21 feet in diameter, and which is hung upon the horizontal crank shaft of the engine. This disc, which is hollow and of wrought iron, is virtually an air-pump, and it is divided into a number of small chambers. When the disc is in motion, these, like so many mechanical fans, gather air at the centre and emit it at the circumference. It is intended that this centrifugal disc shall make 300 revolutions per minute; and as its centre is to be in direct communication with the interior of the conveyance, or vacuum tube, it is clear that this latter may be exhausted to an extent governed by the speed of the disc, and the weight on the relief or regulating valve opening into the tube. The tube itself consists of a series of cast iron socket-ended pipes in 9 feet lengths, jointed together with molten lead, and resembling in sectional forms the old-fashioned wagon-ended boiler of Watt. The height of the tubes from floor to roof, so to speak, is 2 feet 8 ins., and their width also is 2 feet 8 ins. The upper part or roof is semicircular, whilst the lower part is nearly flat. Along the two sides of the base of the tube run narrow longitu-

dinal flat surfaces formed in the castings, and these constitute the tramway upon which the carriages are to travel.

The carriages themselves are made of stout boiler-plate. They are about 4 feet 6 inches in length, have a deep hold for the reception of their cargo of letters, parcels, merchandise, and are each mounted on four small wheels of cast iron. The carriages are of the precise form of the tube, and though they by no means fit its interior closely, they yet may be said to represent pistons. About a quarter of a mile of this tubing has been laid down, and it connects the engine-house at Euston with the North-Western District Post-Office in Eversholt St., Camden-town. At each end of the conveyance pipe, as we may henceforth term it, an iron cover of sufficient area to seal its mouth is hinged. These covers have been faced in the lathe, and, when lying on their diagonal seats, form air-tight joints. Such are the main features of the apparatus of the Pneumatic Despatch Company, as at present established, and almost perfected for trial at the place indicated.

It will now be understood, if our explanation is sufficiently lucid and minute to make it so, that it is quite possible to pump the air from the conveyance pipe. Well, then, supposing it be desired to transfer a loaded carriage from the Post-Office to the railway station, it will be simply necessary to push it (the carriage) forward on rails corresponding with those in the inside of the tube, close the engine-house end, start the disc, remove the air from the front of the carriage, and allow the external atmosphere to push it forward to its destination. The speed at which it will travel will depend on the extent of the vacuum, which is again determined as we have described. This operation may be justly termed "sucking" the mail.

It may seem strange to some that the carriages do not fit the pipe, and the possibility of forming a vacuum at all, under such circumstances, might well be questioned; but the answer is, that the area of the end of the carriage is great, the vacuum low, and the air-space or windage, consequently, not sufficiently large to allow of the "killing" of the vacuum by the rush of air through it. The atmospheric pressure will not, as a rule, exceed 5 lbs. on the square inch.

At the head of this paper we speak of "blowing" the mail, as well as sucking it. This operation the Pneumatic Despatch Company propose to do by inverting the action of the disc, and causing it thus to force or blow air *into* the conveyance pipe, instead of pumping it *out*. It is evident that it is as necessary to be able to send parcels, &c., from Euston to Eversholt Street, as to despatch them from Eversholt Street to Euston. This can only be done by erecting an engine and accessories at the Post-Office, as well as at the station, or by *blowing* the carriages one way, and *sucking* them the other. We are of opinion that in the *blowing* part of the process failure awaits the company's exertions. The power required to displace the air in front of the carriages, and move them at any speed, will be very great, and the cost of doing it excessive—at least, we think so. It would be much more advantageous to continue the conveyance pipe to a greater distance—say, some four or five miles, even to the General Post-Office, and then

erect "sucking" apparatus at both ends. No doubt the transport of the Camden-town machinery from Battersea-fields, and its re-erection, have been attended with considerable expense, as we know they have with much difficulty. The laying of a large tube at a depth of four or five feet below the surface of a street—that street being already occupied by a net-work of gas and water mains, with their connexions—is in itself no trifling task. It is to be trusted that final success will repay the shareholders for the labor and the money which have been expended. It may be stated, finally, that the non-fitting of the carriages enables them to pass freely over steep gradients and sharp curves, which is fortunate, for these will have frequently to be encountered in laying conveyance pipes through the great thoroughfares of London. Messrs. Rimmell and Clarke are the engineers, and James Watt & Co. constructed the engine and machinery.—*Building News.*

Inspection of the Pneumatic Despatch, by the POSTMASTER GENERAL and Sir ROWLAND HILL.

From the London Mechanics' Magazine, February, 1863.

On Monday last Lord Stanley of Alderly, the Postmaster General, and Sir Rowland Hill, the Secretary to the Post-office, officially inspected the working arrangements of the branch tube of the pneumatic despatch (which has been laid from the Euston station to the north-western post-office in Eversholt street), previous to the transmission of the mails between the two places above mentioned, the post-office authorities having conceded this privilege to the Pneumatic Despatch Company. The time appointed for the inspection was half-past 12 P. M., and on the arrival of the Postmaster General and Sir Rowland Hill at the station, within the boundary of the Euston terminus, they were received by Sir Charles Rich, one of the directors; Mr. Margary and Mr. Rammell, the secretary and engineer of Pneumatic Despatch; Messrs. Blake and Stewart of the London and North Western Railway, being among those present. The working arrangements were thoroughly explained by Mr. Rammell, the engineer, and trains of cars were rapidly propelled backwards and forwards through the tubes. The cars contained heavy weights, being principally loaded with stout planks, and on the signal being given by Wheatstone's admirable telegraph, they were despatched to the other end of the tube, with a pressure of about 4 ounces, in a few seconds over a minute, the average up the incline being about 1 minute 12 seconds, returning by vacuum in 1 minute 5 seconds. The mail bags, upwards of 120 per day, will be blown through the tube in 55 seconds to the post-office, Eversholt street, the usual time occupied by the mail carts being at present about ten minutes. Two persons were conveyed, in the presence of the post-office authorities, through the tube, and returned by vacuum without having experienced the slightest discomfort. Having fully examined the operation of blowing the cars from Euston, the visitors proceeded to the station at the other end of the tube. This is

situated underground, beneath the roadway of a small turning leading from Eversholt street, and is close by the side of the north-western district post-office. Here the very interesting operation of sending the cars back to Euston was explained by Mr. Rammell, and two cars having been placed within about a foot of the open tube, a vacuum was created and they were drawn with a rush into the tube, the small station reverberating with the sound of the receding train. This concluded the experiments of the day, and on leaving, both Lord Stanley and Sir Rowland Hill appeared favorably impressed with the entire working of the system—the Postmaster General observing that it appeared from the experiments to be very satisfactory and very efficient. Previous to leaving the station at Euston, Lord Stanley descended with Mr. Rammell into the air chamber of the revolving disc, the motive power of which consists of a 15 horse power engine. The next step of the company will be to lay tubes connecting the markets of London with Camden goods station with a tube to the general post-office, and Pickford's depot in Gresham street, and these operations will eventually tend to revolutionize the carrying system of the metropolis, and relieve the crowded state of our principal thoroughfares.

Proceedings of the Association for the Prevention of Steam Boiler Explosions, Manchester.

From the Lond. Mechanics' Magazine, January, 1863.

[Abstract from the Chief Engineer's Monthly Report.]

During the past month, ending Dec. 31st, 1862, there have been examined 430 engines—3 specially; 621 boilers—12 specially, 9 internally, 54 thoroughly, and 556 externally, in which the following defects have been found:—Fracture, 4; corrosion, 33 (1 dangerous); safety valves out of order, 13 (2 dangerous); water gauges, ditto, 24; pressure gauges, ditto, 9; feed apparatus, ditto, 1; blow-off cocks, ditto, 32 (1 dangerous); furnaces out of shape, 7, (2 dangerous); blistered plates, 1. Total, 124 (6 dangerous). Boilers without glass water gauges, 6; without pressure gauges, 16; without blow-off cocks, 27; without back pressure valves, 44.

Explosions.—While I am happy to be able to report that no explosion has happened during the past month to any of the boilers under the inspection of this association, the occurrence of five explosions in other quarters during that period has come to my knowledge. Each of these has been attended with fatal consequences, 26 persons in all having been killed, and upwards of 32 injured. Two of the exploded boilers were personally examined.

The first of these explosions, and from which 10 persons were killed and 26 injured, occurred at an iron works. The boiler was a horizontal one, of plain Cornish type, with a single internal flue, and a longitudinal steam chamber fixed above the shell. It was heated, as is common in such works, by the flame passing off from the iron furnaces; the flames of one of these passed through the internal flue in one di-

rection, and those from two others passed outside the shell in the other direction. The furnaces were placed immediately at the ends of the boiler, one at one end and two at the other.

The dimensions of the boiler were as follow:—Length, 25 ft.; diameter of the shell, 5 ft. 3 ins.; of the internal flue tube, 2 ft. 3 ins.; thickness of the plates, three-eighths throughout, with the exception of the flat ends, which were half-inch, and strengthened with gussets in the ordinary way.

The wreck was so complete that scarcely a trace of the fittings remained; but they are reported to have consisted of two safety valves 2½ ins. in diameter, a float, and glass water gauge; which latter, however, had been broken a short time previous to the explosion; while there remained on the ground the feed back pressure valve and the feed stop tap.

The load on the safety valve was stated to have been 70 lbs. on the square inch; but the boiler had not been fitted either with a steam pressure gauge or with a tap for applying the indicator, so that no means had existed of checking the actual pressure when the steam was up.

The rents in the boiler, as well as the flight of the parts consequent on explosion, were extremely complicated, and are difficult clearly to describe. Generally, it may be stated that the shell and internal flue tube had been completely torn asunder one from the other, and that each of the end plates, gusset stays and all, had been wrenched from both shell and tube. To go more into detail. The shell had been rent transversely into two parts, and the longitudinal steam chamber dismantled. The internal flue tube had collapsed and separated into four lengths, fracturing at the ring seams of rivets. The longitudinal seams which were at the sides of the tube ran in line from one end of it to the other, and the collapse, which is usually vertical, was in this case lateral, and had brought these longitudinal seams from each side of the tube close together. This was the case in each segment of this disjointed tube. The end plates, which had been built in pieces, were separated at each of the seams, and disengaged from the shell and flue tube by shearing both rings of angle iron. One gusset adhered to the end plate, but in the main they were torn away from both end and shell. There were many minor fragments, which were completely curled or crumpled up.

With regard to the flight of the parts generally, the shell had flown in one direction and the internal flue tube in the other; although this admits of some exception, one portion of the tube being found alongside the shell in a contrary direction to the others. The end plates had also flown in directions opposite one to the other, the fragments of each being scattered a considerable distance apart, and some of them flying to a greater distance than either the flue tube in one direction or the shell in the other.

The devastation to the surrounding property from the explosion was very considerable, arising greatly from the fact that the heavy portions of the boiler had taken a horizontal raking course, the shell flying into the heart of the works, where it swept the columns, and

thus brought down a considerable portion of the roof, and also struck and broke in pieces a heavy rolling mill fly-wheel then in motion. Boilers flying vertically are seldom productive of an equal loss either of life or property. The damage, however, was not confined to that done by the flight of the parts. The percussive action of the steam had shot in every direction the bricks, many of them red hot, from the furnaces previously referred to as built at each end of the boiler. The chimney, about 130 ft. high, was scarred to the top, showing the height to which the parts had been thrown.

The cause of the explosion was attributed at the inquest to shortness of water, which leading to overheating of the plates had, it was supposed, on the re-introduction of the feed, resulted in a sudden and excessive pressure of steam. This was imputed to the carelessness of the engine tenter, and the jury found him guilty of manslaughter, in consequence of which he was committed to the next assizes for trial.

There is good reason to question the correctness of the above conclusions, and to attribute the explosion to other causes than shortness of water and the negligence of the engine tenter.

The pressure of 70 lbs. to the inch, at which the safety valves were stated by the manager of the works to have been loaded, was excessive for a boiler of such construction; not so much so for the shell as for the internal flue tube, the latter not being half the strength of the former. This must have been the case even when the boiler was new, and if the tube was perfectly circular; but since then the tube had been repaired, in consequence of overheating, and very frequently a good deal of straining occurs in replacing old plates; also, many tubes are found on actual measurement not to be truly circular, although nominally so; and had this been the case in this instance, its strength would have been considerably less than half that of the shell. In attempting to unravel the complicated rents produced in boilers on explosion, it is important to bear in mind that girder strains and leverages, the amount of which it is difficult to calculate, are induced in the plates as soon as the statical equilibrium is disturbed by the occurrence of a rent. Collapse of flue tubes has been found in other cases to break them up into short lengths at the ring seams, and to sheer the end angle iron through at the roots, as was the case in this instance.

Upon careful consideration of all the circumstances, to enumerate the whole of which would be tedious, there appears every reason to believe that the explosion resulted from the collapse of the flue tube consequent upon its inherent weakness, and not from shortness of water; while that collapse might have been prevented, either by the introduction at the time of the construction of the boiler, of flanched seams, or hoops of T iron, angle iron, or other approved form, or else by the addition to the flue, since it was made, of angle iron hoops.

The second explosion, which resulted in the loss of three lives, was of a much simpler character than the one just referred to, and occasioned scarcely any damage to property.

The boiler was of plain double-flued internally-fired construction, such as is in general use at cotton mills in Lancashire. Its length was 25 feet 6 inches; the diameter of its shell, 7 feet 6 inches; and of its internal furnace tubes, 2 feet 10 inches; the thickness of the plates in both being from three-eighths to seven-sixteenths. The fittings were complete as to number, as well as satisfactory as to condition, and all that was necessary with due care for safe working. The working pressure was stated not to have exceeded thirty-five pounds, and there was no reason to doubt the correctness of this, while the boiler was perfectly capable of working safely at a much higher pressure, as long as it was in good condition.

On examining the boiler it was at once apparent that it had not exploded either from excessive pressure or shortness of water, but from thinning of the plates through external corrosion, from which a rent was found to have occurred in the last ring of plates of the shell in the left hand flue immediately above the brick-work on which the boiler rested, it being set on what are termed side walls. This rent extended longitudinally through the solid of its plate, throughout its whole width, from one ring seam of rivets to the other, but opened only a few inches transversely, forming a slot, the edges of which were blown outwards into the form of lips. The plate at this part was reduced by corrosion to the thickness of a sheet of brown paper, and some pieces were broken off with the fingers by one of the jury as specimens. It may be added, that daylight could be distinctly seen through the adjoining plate, which had not been disturbed from its original position by the explosion, but was completely eaten through by corrosion in the form of veins, so that either leakage must have been going on at this part for some time, which, however, it can scarcely be imagined could have escaped detection, or else the plate must have depended on a coating of scale, such as was to be found in other parts of the boiler, for keeping it tight.

It is unusual for a longitudinal rent in a cylindrical shell to confine itself to such narrow limits as this had done, and the fact is to be attributed to the proximity of the end plate and the lowness of the working pressure.

The rush of steam and water had blown up the upper part of the brick-work flue, but the boiler was not moved from its place, and no further damage to property appeared to have been done. The loss of life occasioned by the explosion resulted from scalding, the persons killed being in the boiler room at the time.

The corrosion, which, as previously stated, was external, was caused by damp in the flue, the plates being most seriously affected for a considerable distance along the seating, in addition to the part actually rent. This was at once apparent upon entering the flues, where large cakes of oxide were readily collected. Competent inspection could not have failed to have detected the corrosion and prevented the explosion. The flues were stated to have been swept out about once a year, only, whereas this should be done at least every three months, not only to prevent the loss of fuel that must result from an accumu-

lation of soot, but also in order to afford an opportunity of examining the condition of the plates.

The present may be a fitting occasion for again urging upon the members of the association the importance of affording the opportunity of making "internal and thorough" examinations of their boilers. The facts of the second explosion speak for themselves; while in connexion with the first, with reference to the collapse of the flues, it may be stated that when these "thorough" examinations are made the flues are then gauged in order to check their circular shape; this is too frequently found to vary as much as one or two inches from the truth, which has a considerable influence upon their safety, and may render strengthening hoops necessary where otherwise unsuspected.

Progress during the year 1862.—The following points have been accomplished during the past year:

It is gratifying to find that the members now appreciate more fully than heretofore the importance of annual "thorough" examinations, and that the number has consequently increased from 434 in the year 1861, to 820 in the year 1862; thus, as it will be seen, having almost doubled this last year as compared with the previous one.

Still the privilege afforded by the association is an "internal and thorough" examination of every boiler once a year, so that the full number has not even yet been attained, and members will not derive that safety from the service of the association which they might, until every boiler, without exception, is examined by its inspectors, both "internally and externally" every year.

The introduction of "surface blowing out" for the removal of incrustation—a difficulty most severely felt in this district, both by inspectors and steam users—has during the last year, made considerable progress. There are three different kinds of scum-pipes now in use. One entirely free from patent right, and which may be made and applied by any one, and was described in the printed abstract of the monthly report for October last, and two others both of which are patented, one being termed the "Needham" and the other the "Shepherd" scum-pipe.

A surface-condenser is being applied to a pair of cotton-mill engines, by which means a constant supply of distilled water for the boilers will be secured. This, in many situations, will prove most valuable, since water, otherwise quite unfit for use, will thus be rendered serviceable.

Steam-jackets so long discarded in this district, have been revived and fitted to the cylinders of some new engines lately laid down, while others are being added to a pair of beam engines already in work.

A superheating apparatus has in two or three cases been applied, for raising the temperature of the steam in its passage between the boiler and the engine.

Each of these movements has an important bearing upon the economic use of steam in this district, and it is thought that information with regard to them will be highly valuable to the members of the association, and, therefore, the results of the working of the whole will be fully investigated and reported to them. The delay in completing the

engines fitted with steam-jackets, consequent upon the depressed state of trade, has prevented their economy being tested during the past year, and with regard to the superheating apparatus, has been in full work for a long period; but the economic result both of the use of the steam-jacket, and of superheating steam, will now be taken into consideration early this year.

It may be added, that there lies at the office for the inspection of the members, a drawing of the scum-pipe referred to, as well as the arrangement of feed-apparatus found to be most convenient. Also a drawing of the method of adding strengthening hoops to flues of boilers when in position; from which, through the neglect of suitable precaution, many flues have been injured, and considerable expense incurred by our members. Also there is a drawing of the method of setting boilers found to be most approved with the best proportions of flues. The plans upon which many under inspection are set are most capricious, and defy all attempts to examine the plates.

A considerable number of "dimension sheets" of boilers under inspection have been added during the past year to the previously very numerous stock in the archive of the association. These show the peculiar construction of each boiler taken; and since, in addition, records are kept of their working, and the repairs they are found to require, these records form a valuable reference for members who are intending either to repair old boilers or lay down new ones. A consultation of these at such times would enable one member to profit by the experience of another, indeed by that of the whole number. Thus any repetition of failures would be prevented, while the success of one would prove of advantage to all. It is thought that this branch of the service afforded by the association is of itself of considerable commercial value to steam users, that it must tend, step by step, to the improvement of steam boilers, and to the completeness of all their arrangements; while such a service could only be rendered by some such system of organization as is to be found in this association.

Magnetic Phenomena.

From the London Athenæum, Dec., 1862.

A notice has appeared in a foreign journal of certain very remarkable magnetic phenomena which were observed in Russia. It appears that while making a survey with pendulum experiments in the neighborhood of Moscow, the officers employed were surprised by finding a marked inclination of the pendulum towards the city. With a view to obtain data for comparison, the observation was repeated at another station some miles distant, and afterwards at others, until an entire sweep had been made round the region, as it may be called, of the ancient capital of Muscovy. But in every instance the result was the same —an attraction, so to speak, of the pendulum towards the city as to a focus. This result is so anomalous, that mathematicians are at a loss to account for it; and it is partly in the hope of eliciting further

information that we publish these particulars. We should like to know at what distance from Moscow the observations were made. Geologists might then be questioned as to the nature of the strata within the circum-perambulated area. Meanwhile this focal attraction remains a very curious subject of speculation.

On the most Recent Spectrum Discoveries. By Prof. Wm. Allen Miller, F.R.S.

[Lecture before the Royal Institution of Great Britain, March 6, 1863.]

From the London Chemical News, No. 172.

The subject of the lecture, the learned Professor said, was perhaps the most extensive and fascinating which presented itself to scientific men. On the present occasion he intended to limit himself to but a few of the interesting discoveries made in this great field of research, and hoped he should not be considered egotistical if he referred to his own experiments. Among the rays emitted by the sun, there were three kinds, interesting as endowed with special action—those which conveyed heat, light, and chemical action. With heat he should have but little to do on this occasion; about light he had something to say; but he was now principally concerned with the rays which manifested themselves by producing chemical action. It was well known that transparent substances did not transmit all these rays with equal facility. Glass was only imperfectly transparent to the chemically active rays, which were found in the most refrangible rays of the spectrum, heat rays being in the least refrangible portion, and light occupying the middle place. It had been found that rock crystal was one of the few substances which perfectly transmitted rays, those highly refrangible, which glass absorbed.

The Professor then showed that some kinds of light were without chemical action, the light from a mixed air-gas flame possessing scarcely any, while that from an ordinary gas flame did possess a little. The oxyhydrogen flame, while attended with intense heat, was endowed with very little chemical action. A prepared collodion plate exposed to this light for twenty seconds gave a very faint picture. But when the flame was thrown on lime, although the temperature was lower, the light had sufficient chemical activity to produce a strong picture on a similarly prepared plate, exposed for the same time. In the case of the chemically acting rays the intensity, number, and position of the lines on the spectrum had been found to vary with the source of light. The most remarkable illustration of this was the different spectra produced by the electric spark of an induction coil between poles of different metals and projected upon a photographic plate.

The spectrum produced by the spark from silver poles, for example, was found to be three times the length of the whole of the solar spectrum transmitted by quartz. In order to obtain views of this invisible spectrum, it was necessary to transmit the rays through a medium more transparent to chemical rays than glass, which, it had been said,

was opaque to the higher rays of this kind, and various experiments had been made to ascertain what substance allowed them to pass most freely. The results were shown in the following table of the

Photographic Transparency of Solids.

Rock crystal,	74	Sulphate of magnesia,	62
Ice,	74	Borax,	62
Fluor spar,	74	Bromide of potassium,	48
Topaz,	65	Thin glass,	20
Rock salt,	63	Mica,	18
Iceland spar,	63	Iodide of potassium,	18
Diamond,	62	Nitrate of potash,	16

The above numbers being founded upon an arbitrary division of the spectrum.

The photographic transparency of liquids differed still more, as would be seen by the following diagram:—

Photographic Transparency of Liquids.

Water,	74	Wood spirit,	20
Alcohol,	63	Acetic acid,	16
Chloroform,	26	Oil of turpentine,	8
Benzole,	21	Bisulphide of carbon,	6

Various gases were also found to interfere with the transmissibility of these rays, as exhibited in the table of the

Photographic Transparency of Gases.

Hydrogen,	74	Benzole vapor,	35
Nitrogen,	74	Hydrochloric acid,	55
Oxygen,	74	Hydrobromic acid,	23
Carbonic acid,	74	Hydriodic acid,	15
Olefiant gas,	66	Sulphurous acid,	14
Marsh gas,	63	Sulphuretted hydrogen,	14
Coal gas.	37		

The diamond and rock crystal allow the chemical rays to pass freely, but other substances, in which no difference of transparency can be discovered by the eye, considerably affect the transmission of these rays. Chloride of potassium allowed them to pass less freely; and nitrate of potash, and the nitrates generally, offered still more obstruction. It was the same with fluids, and also with gases, as would be seen by a reference to the diagrams. It was remarkable, too, that solid bodies when dissolved or melted maintained exactly the same power as when in the solid state. The same was the case when they were converted into vapor, which showed that this power was part of the nature of the substance.

The lecturer then described the phenomenon of fluorescence, and showed that the chemical rays of the spectrum corresponded with the rays of fluorescence by taking a photograph in that part of the spectrum which, though otherwise invisible on the screen, lighted up a solution of æsculine. He then showed that all metals give characteristic photographic spectra, some of them bearing a strong family resemblance to each other, as in the cases of iron, cobalt, and nickel, the last metal giving one of the longest spectra observed, and which extended to 190° of the scale. Arsenic, antimony, and tin showed as

great differences in the invisible as visible part of the spectrum. The most interesting of the metals to study in this respect was magnesium, which opened a wide field for investigation. There were certain points of resemblance between the spectrum of magnesium and that of the sun, which led to the supposition that this metal existed in the solar atmosphere. The comparison of the spectrum of magnesium with that of the sun led also to some important considerations as to the temperature of the sun. It was known that the higher the temperature the more refrangible were the rays of light emitted by a body. We have no conception of the temperature of the electric spark. The heat of the strongest wind furnace was estimated at 4500° F., and that of the oxyhydrogen jet was supposed not to exceed 15,000° F.; yet with neither of these could the same effects be produced as with the electric spark. The lines of the photographic spectrum of magnesium were not seen in photographs of the solar spectrum, and yet there was no doubt that this metal was present in the solar atmosphere. Kirchoff had discovered that solids when heated give a continuous spectrum, but that bodies in the form of gas give rays of definite and limited refrangibility, each substance emitting light of a definite property. He had also noticed that light from a luminous mass, by passing through ignited vapor which, *per se*, would give bright lines in the spectrum, became furrowed out in dark bands occupying exactly the same position in the spectrum as the bright lines. Now, ignited magnesium vapor emitted green rays which were absolutely identical with the group of fixed lines *b* in the solar spectrum, and it was therefore certain that magnesium was a constituent of the sun. It was, moreover, probable that the heat of the sun was inferior to that of the electric spark, inasmuch as it was insufficient to bring out the highly refrangible lines observed in photographs of the magnesium spectrum.

There were thirteen bodies known on earth which these researches lead us to suppose existed in the solar atmosphere. Nor are they limited merely to the sun. Fraunhöfer had examined the spectra of several stars, and found that although they presented no similarity to that of the sun, nor to each other, yet that some general relationship between them was observable.

Mr. Huggins and the lecturer had recently been investigating this subject, and had obtained very perfect maps of the visible spectra of several stars. They had also obtained a photograph of the spectrum (which was exhibited) of Sirius. This star is 130,000,000,000 of miles distant, and the light which produced the photograph must have left it twenty-one years ago.

A photograph of the spectrum of Capella, which is three times further distant than Sirius, had also been obtained, the light to produce which, the lecturer said, must have left that star when the oldest in the room was a little boy. Professor Miller concluded an eloquent address, of which the above is a mere outline, by remarking how much these wonderful facts enlarged our ideas of the power of the great Author of the universe, whose will "creates, sustains, and animates the whole."

SUBMARINE CABLES.

Date when laid.	From	To	No. of Conductors.	Size per Birmingham Wire Gauge.	Size of Gutta Percha per Birmingham Wire Gauge.	Outside Wires. No.	Outside Wires. Size.	Length of Cable in Statute Miles.	Length of Insulated Wire in Statute Miles.	Depth of Water in Fathoms.	By whom Manufactured.	Length of time the Cables have been working. Years.
1851	Dover,	Calais,	4	16	2	10	1	27	108	. .	Wilkins & Wetherley, Newall & Co., Kuper & Co., and Mr. Crampton,	11
1852	Holyhead,	Houth,	1	. .	. .	12	. .	73	73	. .	R. S. Newall,	. .
1853	Denmark, across the Belt,		3	18	4	9	2	18	54	. .	R. S. Newall & Co.,	9
1853	Dover,	Ostend,	6	16	2	12	2	80¼	483	. .	Newall & Co., and Kuper & Co.,	9
1853	Frith of Forth,		4	16	1	10	8	5	20	. .	R. S. Newall & Co.,	9
1853	Portpatrick,	Donaghadee,	6	16	2	4 cables	galvanized.	25	150	. .	" "	9
1853	England,*	Holland,*	1	16	1	12	2	480	480	30	" "	9
1854	Portpatrick,	Whitehead,	6	. .	. .	10	8 galvanized.	27	162	. .	" "	. .
1854	Sweden,	Denmark,	3	16	No. 2	10	2	12	36	14	Glass, Elliot & Co.,	8
1854	Holyhead,	Houth,	. .	. .	. .	. .	. .	73	73	. .	R. S. Newall & Co.,	8
1854	Italy,	Corsica,	6	16	1	12	1	110	660	325	Glass, Elliot & Co.,	8
1854	Corsica,	Sardinia,	6	16	1	12	1	10	60	20	" "	8
1855	Varna,	Constantinople,	. .	. .	. .	. .	. .	172	172	. .	Newall,	7
1855	Varna,	Balaklava,	. .	. .	. .	. .	. .	356	356	. .	"	7
1855	Egypt,		4	16	2	10	1	10	40	. .	Glass, Elliot & Co.,	7
1855	Italy,	Sicily,	3	16	2	10	1	5	5	27	" "	7
1856	Newfoundland,	Cape Breton.	1 strand.	14	1	12	9	85	85	360	" "	6
1856	Prince Edward's Island,	New Brunswick,	1 "	14	1	12	9	12	12	14	" "	6
1857	Norway, across	Fiords,	1 "	14	1	10	6	49	49	300	" "	5
1857	Sardinia,	Malta,	. .	. .	. .	. .	. .	700	700	. .	Newall & Co.,	. .
1857	Malta,	Corfu,	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
1857	Across mouths of	Danube,	1 "	14	1	12	9	3	3	. .	Glass, Elliot & Co.,	5
1857	Ceylon,	Mainland of India, &c.,	1 "	14	⅝	. .	8	30	30	. .	" "	5
1857	Sardinia,	Bona,	4	. .	. .	. .	. .	125	500	. .	Newall & Co.,	3
1858	Italy,	Sicily,	1	16	2	10	1	8	8	60	Glass, Elliot & Co.,	4
1858	Dardanelles,	Scio and Candia,	. .	. .	. .	. .	. .	514	514	. .	. .	4
1858	England,	Holland,	4	13	0	10	. .	140	560	30	Glass, Elliot & Co.,	4
1858	"	Hanover,	2 strands.	16	3	12	6¼	280	560	30	" "	4
1858	Norway, across	Fiords,	1 "	14	1	10	6	16	16	300	" "	4
1858	South Australia,	King's Island,	1	16	1	10	8	140	140	45	W. T. Henley,	4
1858	Weymouth,	Alderney,	. .	. .	. .	. .	. .	93	93	. .	. .	4
1858	Ceylon,	India,	1	14	⅝	12	8	30	30	45	W. T. Henley,	4

*Fourteen separate cables of 120 miles each.

SUBMARINE CABLES. (Table continued.)

Date when laid.	From	To	No. of Conductors.	Size per Birmingham Wire Gauge.	Size of Gutta Percha per Birmingham Wire Gauge.	Outside Wires. No.	Outside Wires. Size.	Length of Cable in Statute Miles.	Length of Insulated Wire in Statute Miles.	Depth of Water in Fathoms.	By whom Manufactured.	Length of time the Cables have been working.
												years.
1858	Ireland,	Newfoundland,	. .	. .	. .	. .	. .	2,222	2,222	. .	Glass & Elliot, & Newall & Co.,	. .
1859	Singapore,	Batavia,	. .	. .	. .	. .	. .	550	550	. .	Newall & Co.,	3
1859	Athens,	Syra,	. .	. .	. .	. .	. .	117	117	. .	" "	3
1859	Alexandria,	"	4	16	3	10	1	2	8	. .	Glass, Elliot & Co.,	3
1859	England,	Denmark,	3 strands.	16	3	12	5½	368	1,104	30	" "	3
1859	Sweden,	Gotland,	1 "	14	1	12	9	64	64	80	" "	3
1859	Folkestone,	Boulogne,	6 "	14	3	12	. .	24	144	32	" "	3
1859	Across rivers,	in India,	1	13	0	9	2	10	10	. .	" "	3
1859	Malta,	Sicily,	1 strand.	14	1	10	5½	60	60	79	" "	3
1859	England,	Isle of Man,	1	16	2	10	6½	36	36	30	" "	3
1859	Jersey,	Pirou in France,	1 strand.	14	3/8	12	5½	21	21	15	" "	2
1859	Tasmania,	Bass Straits,	1	16	1	10	8	240	240	. .	W. T. Henley,	2½
1859	Liverpool,	Holyhead,	2	16	3	12	6	25	50	. .	Glass & Elliot,	2½
1859 / 1860	Suez,	Kurrachee,	1	. .	. .	. .	. .	3,499	3,499	. .	R. S. Newall & Co.,	. .
1860	France,	Algiers,	1 strand.	14	. .	10	14 *	520	520	1,585	Glass, Elliot & Co.,	2
1860	Corfu,	Otranto,	1 "	14	. .	10	5½	90	90	1,000	" "	2
1860	Denmark,	Great Belt, 14 miles, 14 miles,	6 3	16	1 1	12 10	1	28	126	18	W. T. Henley,	2
1860	Dacca,	Pegu,	1	13	. .	18	14	116	116	. .	" "	2
1860	Barcelona,	Mahon,	1	14	1	16	12½	180	180	1,400	" "	2
1860	Minorca,	Majorca,	2	16	3	18	12	35	70	250	" "	2
1860	Iviza,	Majorca,	2 strands.	16	3	18	11¼	74	148	500	" "	2
1860	St. Antonio,	Iviza,	2 "	16	3	18	11¼	76	152	450	" "	2
1861	Norway, across	Fiords,	1 strand.	14	1	10	6	16	16	300	Glass, Elliot & Co.,	1½
1861	Toulon,	Corsica,	1 "	14	. .	10	14 *	195	195	1,550	" "	1½
1861	Malta,	Alexandria,	1 "	8	¼	18	11	1,535	1,535	420	" "	1
1861	Newhaven,	Dieppe,	6	. .	. .	. .	. .	62	372	. .	" "	1
1862	Abermawr, Pembroke,	Grenore, Wexford,	4 "	14	1	12	3	63	252	58	Glass, Elliot & Co.,	6 mos.
1862	England,	Holland,	4 "	13	. .	10	. .	130	520	30	" "	2 "
1863	Cape Carbalnara,	Trapani,	1	. .	12	10	. .	200	200	200	" "	. .
1863	Persian Gulf,	" *	. .	. .	. .	. .	. .	20	20	. .	Hall & Wells,	. .
	In Germany, Russia, &c.,	"	. .	. .	. .	. .	. .	1,000	1,000	. .	Felden & Guilleaume,	. .
		* Steel covered with hemp.										
						TOTAL,	. .	15,176½	1,9549			

New Thermometer.

From the London Practical Mechanic's Journal, May, 1863.

Dr. Joule made the following communication respecting a new and extremely sensitive thermometer:—"Some years ago I remarked the disturbing influence of currents of air on finely suspended magnetic needles, and suggested that it might be made use of as a delicate test of temperature. I have lately carried out the idea into practice, and have obtained results beyond my expectation. A glass vessel in the shape of a tube, 2 feet long and 4 inches in diameter, was divided longitudinally by a blackened pasteboard diaphragm, leaving spaces at the top and bottom, each a little over 1 inch. In the top space a bit of magnetized sewing needle, furnished with a glass index, is suspended by a single filament of silk. It is evident that the arrangement is similar to that of a 'bratticed' coal pit shaft, and that the slightest excess of temperature on one side over that on the other must occasion a circulation of air, which will ascend on the heated side, and, after passing across the fine glass index, descend on the other side. It is also evident that the sensibility of the instrument may be increased to any required extent, by diminishing the directive force of the magnetic needle. I purpose to make several improvements in my present instrument, but in its present condition the heat radiated by a small pan, containing a pint of water heated 30°, is quite perceptible at a distance of 3 yards. A further proof of the extreme sensibility of the instrument is obtained from the fact that it is able to detect the heat radiated by the moon. A beam of moonlight was admitted through a slit in a shutter. As the moon (nearly full) traveled from left to right, the beam passed gradually across the instrument, causing the index to be deflected several degrees, first to the left and then to the right. The effect showed, according to a rough estimate, that the air in the instrument must have been heated by the moon's rays a few ten-thousandths of a degree, or by a quantity no doubt the equivalent of the light absorbed by the blackened surface on which the rays fell." Proc. Manchester Literary and Philosophical Society, March 16, 1863.

Machinery Belting.

From the Lond. Mechanics' Magazine, March, 1863.

There is no simpler, or smoother means of communicating motion than that afforded by the noiseless agency of cords, bands, or straps. The very means by which the motion is maintained, namely, by the frictional adhesion between the surfaces of the belt and the pulley, is a safeguard to the whole mechanism; as if any unusual or accidental obstruction should intervene, the belt merely slips, and breakage and accident is thus prevented. When, however, the motion is required to be conveyed in an *exact* ratio, belts are inapplicable, from their tendency to slip. Slipping may, no doubt, be prevented by various means; but it will be shown in the following interesting investigation

that, even where the precise action known under the name of slipping does not occur, there is, nevertheless, a certain amount of inaccuracy in the transmission of the speed.

We have extracted the following from the first number of *Annales des Mines*, of last year:—

It is generally admitted that in any transmission of movement by means of belts, the speed of the driving shaft is communicated to the shaft driven, at a velocity inversely as the respective diameters of the pulleys; of course, supposing that the belt has sufficient initial tension to prevent any slipping.

We shall endeavor to prove that a rigorously exact communication of speed can scarcely ever take place, and that the shaft driven always revolves somewhat slower; and, further, that this diminution of speed is often sufficiently great to require an allowance in calculating the diameters of a set of pulleys.

If we suppose a pulley A, communicating motion by means of a belt to a pulley B, fixed on a shaft parallel to that of the pulley A; let R be the radius, and w the angular velocity of the pulley A; and further, R^1 the radius, and w_1 the angular velocity of the pulley B. We will now suppose that a force F is acting at a tangent to the pulley B, and in a contrary direction to the motion.

In order that a uniform movement should take place, the driving portion of the belt must take a tension T, and the strap that is lead a tension t, while the difference of these two tensions $T - t$ must be equal to F. But the belt is made of an elastic substance, continually changing from one tension to another, and thus altering its length, so that if we fix upon any two points of the belt in motion, the distances between these two points will vary with the tension the part under consideration is undergoing. Whatever be the general law of the variation of tension of the strap at the different points, it is evident that the movement of this belt has all the character of *permanent* motion, and that, in consequence, the quantity of matter passing over the different points in the same time is the same; it is necessary, to produce this effect, that the *natural length* of the strap passing at the different points during the same time be constant. We understand by *natural length* of a part of a belt submitted to a certain tension, the length that such a portion of the belt would have if there were no tension. If we call l the *geometrical length* of the belt, at a tension t, rolling itself within a time O, over the pulley B, a *geometrical length*, l^1 of the belt at a tension T will unroll itself during the same time, and this length will be such that its *natural length* will be the same as that corresponding to the lapped round part t. It is thus clear that, contrary to the common belief, the *geometrical length* of the part of the belt rolling itself round the pulley during a time O, is less than the geometrical length that unrolls itself during the same time, and, as a consequence, that there is necessarily a slip on the pulley in the direction of the motion.

It will also be seen that the geometrical length of the belt lapped round in the time O, by the pulley A, is larger than the geometrical

length that unrolls itself during the same time, and there is, consequently, a slip of the belt in a contrary direction to the motion.

If we express the equality of the *natural lengths* of belting lapped round during a time θ by the pulleys A and B, we shall have, represented by a, the stretching of the unity of length of the belt under the influence of the unity of tension:—

$$\frac{R w \theta}{1+a T} = \frac{R' w' \theta}{1+a t}$$

from which

$$\frac{w'}{w} = \frac{1+a t}{1+a T} \cdot \frac{R}{R}$$

We thus see that the ratio of the speeds is equal to the inverse ratio of the radii multiplied by a co-efficient, that is only equal to unity when these two tensions are equal—that is to say, in case there is no work to be transmitted, or in case the initial tensions of the belt be infinitely great. The speed is thus always more or less diminished, and the means generally adopted—namely, to tighten the belt, and thus increase the initial tension—is a more injurious than useful remedy, as it increases the passive resistances to the transmission of motion. It is easy to determine the average amount of this co-efficient of the diminution of speed. The writer recently made a series of experiments to determine the value of a. He found, taking for unity of length the metre, and for unity of tension the kilogramme, that

$$a = \frac{0{\cdot}16^{m.}}{s}$$

for belts of common leather that had been in use for some time; and

$$a = \frac{0{\cdot}21^{m.}}{s}$$

for new belts, s representing the section of the belt in square millimetres.

In practice it is generally admitted that a leather belt carries ¼ kilogramme per square millimetre in section, that is to say, that $s = 4T$; we would thus have

$$a T = \frac{0{\cdot}16}{4}$$

for belts that have been in use for some time, and

$$a T = \frac{0{\cdot}21}{4}$$

for new belts.

As to $a t$, it is equal to $a T \times \frac{t}{T}$.

We can have an approximate value of $\frac{t}{T}$; in fact the strengths of belts are always calculated in such wise that they can resist the tension required to prevent a complete slipping on the drum. We are not now

referring to the slipping caused forcibly on the drum by the lengthening of the strap, but of a slipping produced simultaneously in the whole part of the strap rolled on the drum, and resulting in a cessation of motion to the pulley driven. It is generally demonstrated that, to render this complete slipping impossible, we must have (tension) $T < te^{fb}$, f being the co-efficient of friction of the belt on the drum, and b the ratio to the arc of the pulley embraced by the strap to the radius of the pulley. In practice T is generally made $= 0{\cdot}9.\ te^{fb}$, a ratio that, in the case of a leather strap embracing a cast iron pulley, becomes $T = 2{\cdot}16\ t$. Not to exaggerate the importance of the diminution of speed, we will take $T = 2\ t$, from which

$$at = \frac{aT}{2}.$$

We can easily find that the average value of the co-efficient

$$\frac{1+at}{1+aT}$$

will be—for belts that have been used,

$$\frac{1{\cdot}0225}{1{\cdot}045} = 0{\cdot}978;$$

for new belts,

$$\frac{1{\cdot}0262}{1{\cdot}0525} = 0{\cdot}975.$$

We thus see that the diminution of velocity is about two revolutions for each hundred: this would have but a slight effect on a pair of pulleys; but it is often necessary to use a train of pulleys, and we thus often get very great differences between the real and calculated velocities. It is seen at once that if the co-efficient of the diminution of velocity is 0·98 for a single pair of pulleys, it will become, in many cases, equal to the successive powers of 0·98, which are 0·98...0·96... 0·94...0·92...0·90, nearly; so that, after a succession of five speeds, the loss of velocity is already the tenth of the calculated speed, and that at the end of about thirty-four speeds, the velocity will be reduced to one-half.

The writer has made a great number of experiments to verify these results, and he has determined that, in all cases where the dimensions of the belts do not much depart from those indicated by the calculation, we generally find an average of 0·98 as a co-efficient. The formula has also been verified with great certainty by varying the tensions of the same belt. To produce this effect, the writer employed, instead of a leather belt, a band of vulcanized india rubber, a substance in which a is pretty nearly equal to $\frac{8}{1}$, by which it is possible to acquire a very considerable diminution of speed. This band was placed on two pulleys of equal diameter; a small friction break on one of the shafts allowed the resistances to be altered. A series of equal divisions

marked on the band permitted the tension to be estimated during the motion. The results were perfectly in accordance with the formula.

From all these considerations it appears that, where it is required to transmit determinate speeds by means of bands and pulleys, it is prudent to increase by about one-fiftieth the diameter of the driving pulley, or to diminish the diameter of the following pulleys in the same ratio.

When the power to be transmitted from a prime mover exceeds a certain limit, it is necessary to employ flat belts or straps, working on pulleys, with rims made slightly convex, in a ratio of half an inch per foot of breadth. When the power to be communicated is less than that of two men, cords working in pulleys with round or angular grooves are preferable. Beyond this power a flat belt may be employed, and when certain limits of power and velocity are exceeded, straps must generally make room for toothed wheels. It is well known that long belts give a much better effect than short belts.

Small flat straps are sometimes used instead of hempen or gut cords for smaller machines; this practice, however, is not in general acceptance. A cord is more easily pieced together than a small narrow strap. A leather strap, however, is more elastic than a cord, and is also less hygrometrical, or subject to stretch in wet weather. It is important not to stretch too much belts and straps, as there is otherwise much power lost in producing a given effect. It is generally reckoned that from 1 to 2·2 per cent. of the power communicated is lost by the stiffness of a leather belt. An interesting investigation into this matter will be found, 5 Heft of the "Schweitzer Polytechnischen Zeitschrift" for 1861.

In our volume for 1825, p. 69, will be found a valuable letter from Mr. B. Bevan, giving an account of some experiments to ascertain the strength of leather. The practical table this correspondent gives, is the following:—

	Cohesion — lbs. per sq. inch.	Modulus of cohesion in feet.	Ratio of Extension by half breaking weight.
Calves skin, . . .	1890	5050	0·165
Sheep skin, (basil) . .	1610	5600	0·191
Horse skin, (white) . .	4000	11000	0·187
Horse skin, (Russ) . .	3200	7000	. .
Horse skin, (Cordovan) . .	1680	3720	. .
Cow skin, . . .	3981	10049	0·22

The "modulus of cohesion" is the length in feet of leather required to break its own cohesion, or tear it asunder.

Rule.—To find the weight necessary to break or tear asunder any strip of leather, it is only necessary to ascertain the weight of one foot in length in pounds, and decimals, and multiply the modulus in feet by the weight so found; the product will be the greatest load the strap will bear, even when the leather is new; but not more than one-

third or one-fourth of the weight thus found should be trusted for any considerable time.

The following are some neat formulæ appearing in "Molesworth's Pocket-book of Engineering Formulæ." They are for ordinary leather belting used in common cases, at not very high speeds:—

V = velocity of belt, in feet per minute.

H. P. = horse power (actual) transmitted by belt.

$x = \frac{33000 \text{ H. P.}}{V}$.

S = strain on belting, in lbs.

W = width of single belting ($\frac{3}{16}$th thick) in inches.

$S = x + \frac{x}{k}$.

$W = \frac{S}{50}$.

k = ·09 when portion of driven pulley embraced by belt = 0·40 circumference.

k = 1·3 when portion of driven pulley embraced by belt = 0·50 circumference.

k = 1·6 when portion of driven pulley embraced by belt = 0·60 circumference.

For double-belting the width = W × 0·6.

Approximate rule for single-belting $\frac{3}{16}$th thick.

$$W = \frac{1100 \text{ H. P.}}{V}.$$

An empirical rule for ascertaining the width of pulley straps that we know to be in use by some good practical men, is as follows:—

$$B = \frac{31{\cdot}4 \text{ N}}{n\,d},$$

in which formula, B is the width of strap required (the thickness of the leather being taken at $\frac{3}{16}$th); N is the number of horse power; n is the number of revolutions; and d is the diameter of the pulley.

The most generally used mode of connecting the ends of leather straps is by means of laces or thongs of leather. Other methods have been tried, such as glueing the ends together, or using hooks or clasps. Rivets, studs, and screws have, to some extent, been employed. Pegs have also been employed. (*Vide* Patent No. 3163, 1860.)

The following is a *recipe* for a composition or glue that will stick the ends of belts together. We believe that it has been tolerably successful, and it is said to have stood 4-horse power when carefully made and similarly applied. Take—

8 parts of the best glue,
4 parts of isinglass,
2 parts of gum arabic.

The glue must be boiled down, and stirred up till it assumes a tough, thick consistency. Then pour in three-fourths of spirits of wine, and let it dissolve the mass. The isinglass, previously dissolved in warm

water, is now mixed with the above and stirred up together. Last of all, the gum arabic, dissolved in water, is poured on, the whole carefully mixed together, and the composition is then fit for use.

As might be expected, from the fact of an article being so greatly in demand as leather belting, there are large quantities of cuttings and waste annually evolved from the manufacturer of these useful mechanical organs. Most inventors who have found the means to utilize what was previously refuse, have deservedly accumulated large fortunes. Accordingly, in France and America, attempts, more or less successful, have been made to utilize the waste cuttings of the manufacturers of leather articles. We believe that at Abington, in the State of Massachusetts, there is a steam engine of about 8-horse power solely employed in grinding and pulverizing the waste cuttings usually thrown away or burnt by saddlers, shoemakers, &c. The waste pieces are reduced to powder, and are then mixed with vegetable gums and other substances, by which means the whole obtains such cohesive power that the mass becomes a kind of soluble leather. In a short time the composition acquires sufficient consistency to allow itself to be passed through rollers, and thus to be brought to the required thickness.

Other and more direct means have been attempted to utilize small waste pieces of good leather. Monsieur Roullier, of Paris, himself a manufacturer of artificial leather, has made certain peculiar belts of waste leather cuttings, and some were exhibited at work in the Western Annexe of the International Exhibition. We described his plan in our number for September 19th, 1862.

These "courroies en cuir articules," as they are called by the French inventor, consist of a number of small flat links of $\frac{3}{16}$th leather united by long pins of the breadth of the band. The pins have heads, and are riveted or clenched back on a washer at the other end. In a 3-inch broad specimen of this description of belting, the pins are about $\frac{1}{2}$-inch in diameter, and about $\frac{1}{2}$-inch from centre to centre. The belt working in the French part of the Western Annexe appeared to stand the strain very well. The links of leather are stamped out and the holes punched in by a machine, and they are threaded on to the pins by workwomen. M. Roullier is said to have an establishment in Paris employing 300 workmen, and he can deliver 100 metres per day of his peculiar belting. He has recently used small links of zinc between those of leather. It appears to us that an objection will be found in this belting from the fact that there is necessarily a tendency in the joint-pins to bend to the curve of the pulley, and a continuation of this action would naturally lead to the breakage of the joint-pins.

A very remarkable and important description of belting, the invention of Mr. William Clissold, of Dudbridge, Gloucester, was exhibited at work in the Belgian Department of the Western Annexe of the International Exhibition. These bevel-edged belts were first patented in 1860, May 22d; but not being found sufficiently strong, the *continuous* bevel-edged belts were altered into a kind of chain of separate links. The wedge-shaped links are made of strips of leather coiled up to the ordinary figure of a link, and these links are connected together by

link-plates carrying a stud at either end, which studs enter the adjacent links and hold them together. This description of belt, or rather chain, has acquired great importance from its being used by Mr. John Fowler to communicate the motion of an ordinary portable engine to the movable clip drum in front; by which means the ordinary portable engine can be used in ploughing upon the "direct-acting" system. We also saw some small bands entirely of cotton, at Messrs. Apperley and Clissold's stand in the Western Annexe.

An ingenious and efficient leather belt is manufactured by Messrs. Bryant and Cogan, Broadmead, Bristol, according to the patent of Mr. Haines (No. 406, 1860). These bands are built up of narrow leather strips or fillets, each piece being of the thickness of the intended driving strap, and they are placed side by side with the cut edges of the leather placed outside. The straps are made to break joint, and holes are bored through them at intervals from edge to edge of the strap, and the straps are then fastened together by pieces of wire. It will thus be seen that a description of band like this may be made of any length or thickness, without laps, cross-joints, &c. These bands may also be used much slacker than the common strap, as the rough surface insures a greater amount of adhesion. The band is made a little shorter than the required length, in order that two iron shackles may be kept a few inches apart. As the band stretches, the shackles may be gradually drawn closer, by means of wide laces, until they meet: should the band afterwards stretch, one of the shackles may be set further back by filing off the burr at the end of the pin, cutting back the leather, and inserting the pin through the shackle into the next hole. One of these patent bands was exhibited at work in the Belgian Department of the International Exhibition.

There were several machines in the Western Annexe of the International Exhibition driven by a description of leather belt manufactured by Messrs. Sampson, of Stroud. From its peculiar make no cross-joint was required in a length under 200 feet. It was formed of two narrow strips of thick leather, and three narrow slips were sewn on at the back. There was a slip sewn to each edge, and an additional third strip at the joint in the middle. We have heard practical men say that this belt gave remarkably good results.

We also noticed some excellent double leather bands in the North-East Court of the Eastern Annexe of the International Exhibition. They were exhibited by Webb and Son, of Stowmarket. One of the double bands exhibited was 14 inches in breadth. There were also some edged and single belts. Several patents have also been recently taken out for improvements in treating hides and skins for machinery belting.

Many engineers probably still think that "there is nothing like leather" for straps. Nevertheless, those remarkable vegetable gums, caoutchouc and gutta percha, have been employed in various ways, and with great success, in the manufacture of belting. A large number of these belts were at work in the Western Annexe of the International Exhibition. It is to be regretted that the many extensive

manufacturers of these important mechanical agents have not instituted a series of careful experiments giving the breaking strain, coefficient of friction, loss by stiffness, &c., of india rubber and gutta percha belts, as compared with those of leather.

Most of the india rubber belting sold seems to be very similar in appearance; but the processes of manufacture probably differ. Mr. S. T. Parmelie, of Edinburgh, patented in 1858 (No. 777) certain machinery and a peculiar process for manufacturing belting. The belting is made of several layers of woven material, cut into strips of the width required. The whole is then passed between the peripheries of two rolling cylinders united by an endless metallic band, in such a manner as to admit of the belting being passed between one of the cylinders enclosed within a heated chamber and the endless metallic band. The cylinders are provided with one or more grooves corresponding to the required width of the belting. These bands, which are said to give good results, are manufactured by the North British Rubber Company, Castle Mills, Edinburgh. The woven material that affords the basis for the india rubber, is said to be made of Sea Island cotton. The material is claimed to be superior to leather for damp places, and to gutta percha in situations subject to variations of temperature. The bands are joined together with laces, or by an india rubber lap and screws.

The well-known firms of Warne & Co., Gresham Street, Mackintosh & Co., of Manchester, Hancock, Goswell-mews, and Moses, Son, & Davis, Cheapside, are all manufacturers of india rubber belting, so that it will be seen what an important demand already exists for this description of band.

The belting manufactured by Messrs. Spill, of Stepney-green, according to patent No. 2550, 1859, consists of a band of steel wire, covered with several strands of hempen cord, previously passed through a solution of either india rubber, gutta percha, glue, or drying oils, &c. After the strands have been applied, the whole is carried through rollers. Any number of these smaller bands are then placed as warps in a loom, and similar materials to those covering the steel bands are then used as the weft, so that the whole is woven together. The band is afterwards again passed through rollers, and (either before or after this operation) it is coated with caoutchouc. This invention is also remarkably ingenious.

We have heard some good accounts of the gutta percha bands manufactured by the company of the same name, of City Road, in the metropolis. They are largely used by Truman, Hanbury, Buxton, & Co., as some of the advantages of these bands consist in their non-susceptibility of injury from greasy or chemical substances, and the ease with which the joint may be made. The following are the directions given by the manufacturers for making the joint:—

"Cut the ends of the band obliquely at an angle of 30 or 40 degrees, making the band rather shorter than the length required. Secure one end to a board or bench by a clamp or a couple of nails. Having heated a piece of iron (say 1 inch broad and ½-inch thick) to

the temperature of a laundress's smoothing iron, so that it will soften the gutta percha without burning or discoloring it, place the iron between the cut edges of the band, pressing them against it (keeping the band always in a straight direction) until the edges are thoroughly softened, and in a sticky state; then remove the iron and press the two edges together as closely as possible, after which a couple of nails may be driven into the loose ends of the band, to keep it in its place. The ridge or burr may be pressed down as much as possible into the substance of the band, by a heavy weight or by means of a clamp, so as to make a smooth joint. A band of ordinary thickness will be ready for use in ten or fifteen minutes, or sooner if cold water be applied. Flat joints may be made in like manner, by shaving down the ends a little (so as, when laid one on the other, not to be much thicker than the band), heating the surface of the splices, and pressing them together by a weight or clamp. Avoid heating the band throughout. Pare the edges when cold." Cross-bands made of gutta percha must be separated by a roller, or a fixed round iron bar, if there be much friction or rapid motion.

The West Ham Gutta Percha Company are also manufacturers of similar bands.

An interesting description of belting was exhibited in the American Department of the International Exhibition. It was made chiefly of wool, and the surface of the belt was covered with a resinous cement. We saw a small piece that had been in use for two years and-a-half on a heavy cloth loom in the States. We believe that some belting of this material is working some looms in the Mills of Smith, Brothers, & Co., of Heywood, Lancashire. H.

For the Journal of the Franklin Institute.

Particulars of the Steamship Isis.

Hull built and machinery constructed by Messrs. Charles and Wm. Earle, Hull, England. Route of service, New York to Liverpool. Owners, Messrs. J. Moss & Co., Liverpool.

Hull.—Length on deck, 320 ft. Breadth of beam, 33 ft. Depth of hold, 17 ft. 6 ins. Do. to spar deck, 25 ft. 6 ins. Draft of water at load line, 19 ft. Frame of wrought iron plates, $\frac{7}{16}$ to $\frac{1}{2}$ths of an inch in thickness, and double fastened with rivets $\frac{3}{4}$ inch in diameter, and $2\frac{1}{2}$ ins. apart. Floors—shape, Z—molded, 6 ins.—sided, $\frac{1}{2}$ inch —apart at centres, 17 ins. Keelsons—shape, ⌋⌊. Dimensions of do., 7 by $8\frac{1}{2}$ ins. Number of do., 6. Dimensions of plate stringers, 24 by $\frac{1}{2}$ in. Number of do., 6. Bulkheads, 6. Rig, brig. Tonnage, 1721 tons.

Engines.—Vertical direct. Number of cylinders, 2. Diameter of do., 50 ins. Length of stroke of piston, 3 ft. Maximum pressure of steam, 20 lbs. Point of cutting off, $\frac{3}{4}$ stroke. Revolutions at above pressure, 46.

Boilers.—Two—tubular. Have water bottoms.

Propeller.—Diameter, 18 ft. Pitch, 21 ft. No. of blades, 3. Material, cast iron.

Remarks.—This vessel is worthy of notice, as she is built in the most approved manner. For strength, model, cargo carrying capacity,

&c., she has but few superiors. Her spar-deck is of iron plates. She is fitted with steam pumps, bilge pumps, bilge injections, and all necessary valves. B.

For the Journal of the Franklin Institute.

Particulars of the Steamship China.

Hull built and machinery constructed by Messrs. Robert Napier & Sons, Glasgow, Scotland. Route of service, New York to Liverpool. Owners, British and North American Royal Mail Steamship Co.

Hull.—Length on deck, 353 ft. Breadth of beam, 40 ft. 6 ins.—molded, 3 ins, Depth of hold, 19 ft. 4 ins. Do. to spar deck 27 ft. 6 ins. Draft of water at load line, 23 ft. Frame of wrought iron plates, 1 inch, ¾ and 9-16ths of an inch. in thickness, and double fastened with rivets, 4 ins. apart. Shape of do., Z. Floors—shape,

—molded, 8 ins.—sided, ¾ in.—apart at centres 16½ to 18 ins. Keelsons, 5—all fore and aft. Beam ties, 4—on orlop deck. Dimensions of frame ties, 18 ins. by ¾ inch. Bulkheads, 9. Rig, barque. Tonnage, 2525 tons.

Engines—Oscillating—geared. Number of cylinders, 2. Diameter of do., 80½ ins. Length of stroke of piston, 5 ft. 6 ins. Diameter of piston rod, 10 ins. Maximum pressure of steam, 20 lbs. Point of cutting off, ⅛ to ¼ stroke. Revolutions at above pressure, 62.

Boilers.—Four—tubular. Have water bottoms.

Propeller.—Pitch, 23 ft. No. of blades, 3. Material, cast iron.

Remarks.—This vessel is built in the most approved manner, and is fitted with everything that a steamship of her class demands. B.

For the Journal of the Franklin Institute.

Particulars of the Steamship Victoria.

Hull built and machinery constructed by Mr. Scott Russel, London. Route of service, New York to London. Owners, Messrs. Stock & Co., London.

Hull.—Length on deck, 264 ft. Breadth of beam, 36 ft. Depth of hold, 17 ft. 8 ins. Do. to spar deck, 25 ft. Draft of water at load line, 18 ft. 6 ins. Frame of wrought iron plates, ⅞ to ½ inch in thickness, and fastened with rivets ¾ and ⅞ of an inch in diameter, and 2½ inches apart. Floors—shape, ⅂Z.—molded, 6 ins.—sided, ¾ inch —apart at centres, 18 ins. Keelsons, 2—side. Beam ties, on three decks. Bulkheads, 6. Rig, four masted barque. Tonnage, 1655 tons.

Engines.—Oscillating. Number of cylinders, 4. Diameter of do, 48¾ ins. Length of stroke of piston, 2 ft. 9 ins. Maximum pressure of steam, 15 lbs. Point of cutting off, ½ to ¾ stroke. Revolutions at above pressure, 50.

Boilers.—Four—tubular. Have water bottoms.

Propeller.—Diameter, 18 ft. Pitch, 27 ft. No. of blades, 3. Material, cast iron.

Remarks.—A first class vessel in every respect. B.

For the Journal of the Franklin Institute.

Particulars of the Steamship City of New York.

Hull built and machinery constructed by Messrs. Tod & McGregor, Glasgow, Scotland. Route of service, New York to Liverpool. Owners, Philadelphia, New York and Liverpool Steam Ship Company.

Hull.—Length on deck, 322 ft. Breadth of beam, 40 ft. Depth of hold to spar deck, 27 ft. 6 ins. Draft of water at load line, 23 ft. Frame of wrought iron plates, 1 in. to ¾ of an inch in thickness, and fastened with rivets ¾ of an inch in diameter. every 4½ inches. Floors—shape, L Z.—molded, 6 ins.—sided, ½ inch—apart at centres, 18 ins. Keelsons, 2—side. Beam ties, of wrought iron on main and spar decks. Bulkheads, six. Rig, ship. Tonnage, 2509.

Engines.—Horizontal direct. Number of cylinders, 2. Diameter of do., 85 ins. Length of stroke of piston, 3 ft. 6 ins. Are fitted with Waddell's patent balanced slide valves, and Sewell's surface condenser.

Boilers.—Six—tubular. Have water bottoms.

Propeller.—Diameter, 18 ft. Pitch, 29 ft. No. of blades, 3. Material, cast iron.

Remarks.—This steamship is one of the finest ever constructed. During the period of her service upon the route from New York to Liverpool, she has given perfect satisfaction. In October, 1861, she beat by four hours and some minutes the steamship *Persia* in running from New York to Cork. The *Steam Shipping Chronicle* (London), speaking of these passages, said:—

As a great deal of attention is now being paid to the respective performance of these crack vessels, and as a slight "fog" has crept in over the figures relating to these performances, we are happy to have it in our power to give the details connected with the run home of both vessels. It should be borne in remembrance that the Persia's cargo was 253 tons, whilst that of the City of New York was 746 tons. The latter vessel left New York at noon on the 5th, and arrived at Cork at 11·40 on the 15th, making the run (after deducting 4½ hours difference of time), in 9 days 19 hours. The Persia left at 11 A. M. on the 9th, arriving at Cork at 3 P. M. on the 19th, thus occupying in the run (time corrected), 9 days 23 hours 30 minutes. The following are abstracts of the two logs:—

CITY OF NEW YORK.

Oct. 5.—At 12·15 steamed from the wharf and proceeded slowly down the river, in consequence of the tide; at 3·45 passed Sandy Hook; at 4·35 discharged pilot.

Oct. 6.—Wind light from W. S. W., course E, lat. 40·31, long. 68·24; distance run, 255 miles.

Oct. 7.—Wind light from W. S. W., course N. 72 E., lat. 42·06, long. 61·53; distance run, 310 miles.

Oct. 8.—Wind fresh from S. E., and variable, course N. 53 E., lat. 44·57, long. 56·45; distance run, 282 miles.

Oct. 9.—Wind fresh from S. E., course N. 55 E., lat. 47·35, long. 51·21; distance run, 274 miles.

Oct. 10.—Wind fresh from E. and variable, course N. 57 E., lat. 50·23, long. 46·01; distance run, 268 miles.

Oct. 11.—Wind a fresh gale, with squalls from W. N. W., course E., lat. 50·21, long. 37·50; distance run, 316 miles.

Oct. 12.—Wind a fresh gale from W. N. W., ending more moderate, course N. 85 E., lat. 50·45, long. 29·48; distance run, 304 miles.

Oct. 13.—Wind fresh breeze and squally from N. N. W., course N. 88 E., lat. 50·53, long. 2·256; distance run, 260 miles.

Oct. 14.—Wind W. N. W., moderate breeze and heavy cross sea, course N. 82 E., lat. 51·34, long. 15·15; distance run, 292 miles.

Oct. 15.—Wind variable, course N. 87 E.; at 7·14 A. M., passed Fastnett, 11·40 anchored off Queenstown; distance run to Fastnett, 212 miles.

Oct. 16.—At 1·18 P.M. weighed and proceeded; 8·15 Luskar, 4·45 A.M. South Stack, 7·55 A. M. received pilot, and at 9·44 passed the Rock.

PERSIA.

Oct. 9.—10·50 received the mails; 11 A.M. left New York.

Oct. 10.—Wind E. N. E. fresh, course E. ½ N., lat. 50·53 N., long. 69·36 W.; distance run, 201 miles.

Oct. 11.—Wind S. E. by E., moderate breeze, course E. ½ N., lat. 42·11, long. 64·19; distance run, 249 miles.

Oct. 12.—Wind S. E., increasing breeze with rain, course E. ½ N. lat. 44·02, long. 58·58; distance run, 260 miles.

Oct. 13.—Wind S. E., strong gale with heavy squalls and high sea, lat. 45·45, long. 54·56; distance run, 199 miles.

Oct. 14.—Wind moderate from S. W., course E. by S., lat. 47·10, long. 49·40; distance run, 224 miles.

Oct. 15.—Wind W. S. W., fresh breeze, course E. S. E., lat 49·21, long. 52·56; distance run, 309 miles.

Oct. 16.—Wind S. W., fresh breeze, course S. E. by E. ½ E., lat. 50·32, long. 34·43; distance run, 318 miles.

Oct. 17.—Wind light and variable, course S. E. by E. ½ E., lat. 51·06, long. 26·14; distance run 318 miles.

Oct. 18.—Wind light from S. E., course S. E. by E. ½ E. lat. 51·45, long. 17·46; distance run, 336 miles.

Oct. 19.—Wind light from S. S. W., course various; at 3·30 P. M., arrived at Queenstown, at 3·34 discharged the mails, at 3·40 left Queenstown; distance run, 302 miles.

Oct. 20.—At 5·52 A. M. received a pilot, at 9·20 A. M. arrived at Belle Buoy, and at 10·5 arrived at Liverpool.

During the passage referred to above, and the one the particulars of which are annexed, the *City of New York* was not allowed to run at her full pressure of steam, owing to the newness of the engines, which might easily have become heated:

The British steamship *City of New York*, Capt. Petrie, from Liverpool Oct. 23, *via* Queenstown 24th, at twenty-five minutes past four P. M., arrived at Sandy Hook at half-past eight P. M., on the 2d of November. Oct. 30, at 7 P. M., Cape Race light bore north, distant six miles, but she could not approach in consequence of the heavy southeast sea.

The following is a copy of the log of the *City of New York*.

Date.	Wind.	Course.	Lat.	Long.	Dist.
Oct. 23,	Variable,	. .	. .	. .	. .
Oct. 24,	. .	. .	. .	. .	. .
Oct. 25,	Variable,	S. 86 W.	51·14	13·47	156
Oct. 26,	Variable,	86	50·53	21·43	300
Oct. 27,	South,	85	50·28	29·12	284
Oct. 28,	S. E.,	78	49·28	36·25	285
Oct. 29,	Calm,	79	48·34	43·58	302
Oct. 30,	S. E.,	75	47·18	51·05	296
Oct. 31,	S. E.,	57	44·27	57·10	306
Nov. 1,	Variable,	68	42·42	63·09	279
Nov. 2,	N. N. E.,	66	40·35	69·23	304
Nov. 3,	N. E.,	88	(Sandy Hook)		211

REMARKS.

Oct. 23 and 24—1·50 P. M., passed the Rock; 2·35, discharged the pilot off Belle Buoy; 7·20, off South Stack, strong southerly gale and rain; 5·26 A. M., passed Tuskar; 11·50, Bally Cotton, light winds and cloudy; 12·49, off Roche's Point; 1·28 P. M., anchored off Queenstown; 4·25, weighed and proceeded; 4·50, discharged pilot off Roche's Point; 10·20, west of Fastnett.

Oct. 25.—Light westerley breeze and heavy northwest sea.

Oct. 26.—Light wind and heavy westerly swell.

Oct. 27.—Moderate breeze and cross sea.

Oct. 28.—Light airs and cloudy.

Oct. 29.—Calm and sultry.

Oct. 30.—Light breeze and dense fog.

Oct. 31.—Light breeze and dense fog.

Nov. 1.—Light breeze and strong northwest breeze and clear.

Nov. 2.—Fresh breeze and cloudy.

Nov. 3.—Strong gale and dark cloudy weather; 8·30 P. M., slowed engines; midnight, sounded in eighteen fathoms; 7·15, received pilot. B.

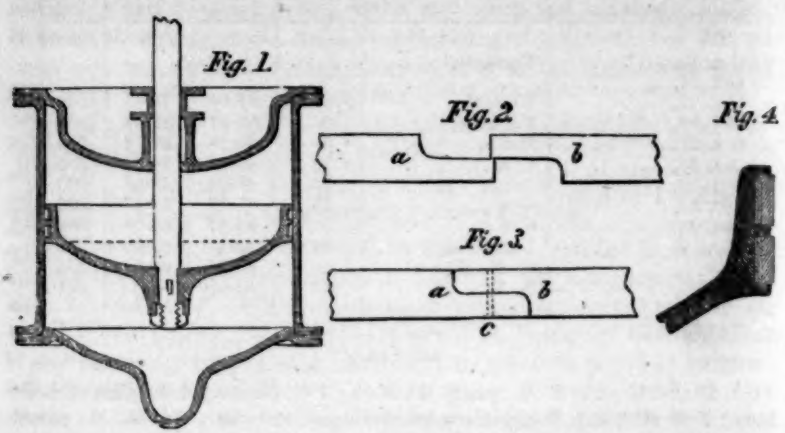
For the Journal of the Franklin Institute.

On Carlsund's Old Steam Piston. By JOHN W. NYSTROM, C.E.

In a late number of the *Scientific American*, and also in some English journals, I have noticed some incomplete statements of the Swedish piston, a steam piston invented by Capt. Carlsund over twenty years ago. The piston is a detail in the steam engine of considerable importance, and a correct description of the one referred to may be found useful to engineers.

Fig. 1 represents a section of a steam cylinder, with Carlsund's piston; figs. 2 and 3, portions of the packing rings; and fig. 4, a section of the periphery part of the piston. The form of the piston is readily understood by the figure; both the cylinder-heads have a similar concave shape. The higher the steam is used, the more concave should be the piston; that in fig. 1 is proportioned to about 30 lbs. pressure to

the square inch. This form makes the piston and cylinder-heads sufficiently strong with very thin metal.



The two packing rings surrounding the piston are made of cast iron, each in one piece, jointed as shown in figs. 2 and 3. The diameter of the rings is cast about the same as that of the cylinder; for large cylinders a little larger, and for small ones smaller.

The rings are turned on the four sides, and the joint cut, as shown in fig. 2; the line *a b* should be perfectly parallel with the sides. The joint is then finished as in fig. 3, with the greatest care that the seam *a b* is perfectly tight, and the outside diameter of the ring a little larger than that of the inside of the cylinder, sufficient to allow for turning. A strap is now screwed around the ring, to keep the joint in position; a hole of about one-quarter the thickness of the ring is drilled in the joint, and a pin *c* inserted. The ring is now placed on a centre-plate turned to the correct diameter of the inside of the ring, the strap taken off, the ring turned to the correct diameter of the cylinder, and the sides to the correct size of the grooves in the piston. This work requires a skilful workman; the last touch on the sides of the rings and of the grooves should be made by a new-sharpened good steel, and the greatest care taken that the rings be not too small for the grooves; should there be any play, it will jar when the piston is in motion. The breadth of the rings is made about 0·3 the square root of the diameter of the cylinder in inches, and the thickness about one-third the breadth.

During my time in Motala, Capt. Carlsund used to put canvass in the bottom of the grooves, but with high steam the canvass will burn. In the engines I have built I put vulcanized india rubber in the grooves, as shown by the dotted part, fig. 4, which is found to answer very well; when the india rubber becomes hot, it expands, and presses the ring gently and uniformly to the sides of the cylinder, and makes the piston perfectly tight. Pistons and cylinder-heads of this form will weigh about one-half of the ordinary clumsy and complicated form.

I have made this piston also in blowing machines and in air-pumps for sugar-works, and found it to answer very well.

Capt. Carlsund has made this piston for all kinds of steam engines for the last twenty years, but the English journals seem to think it best adapted only to locomotives and portable engines.

It is now over thirteen years since I first endeavored to introduce Carlsund's steam piston in America, but did not succeed. A steamship builder who ordered machinery to be made at one of the first establishments in Philadelphia, desired Carlsund's piston to be tried, for which I furnished a complete drawing; but the engineer of the establishment condemned it immediately. I was told that my drawing was shown to the workmen in the establishment, who joined in a hearty laugh and ridiculed the piston. The engineer then made a drawing of the ordinary complicated piston. I was not at the time familiar with the American system of introducing new things, neither would I feel disposed to follow such a course; but simply stated that the piston is very good and in operation in Sweden, and attempted to describe the manner in which it is made. I now regret that I did not give it out as the greatest wonder of the age.

Scientific Balloon Ascent.—The Lines in the Spectrum. By JAMES GLAISHER.

From the London Athenæum, No. 1850.

For the purpose of observing the black lines in the sky spectrum at different altitudes, and the sun spectrum if possible, an apparatus was employed consisting of a prism, a fine adjustable slit half an inch in length, placed in the focus of an object-glass, and a telescope directed to the prism, lent for the purpose by the Astronomer Royal, and is the same apparatus as that used by Prof. Smyth on the Peak of Teneriffe. No angular measure was prepared for or contemplated; only eye observations and comparison of differences between the spectrum as seen on the ground and at different heights during the journey. A careful examination of the spectrum between the hours of 3 and 4 P. M., before starting, showed B as the boundary at the red end, and a little beyond G at the violet end when looking at the sky; and when looking at the sun, I could not see quite to H. The lines C, D double, E, b, and F were very plainly shown, with many lines between them. At 4h. 20m., at the height of about half a mile, a cursory examination of the spectrum showed a close correspondence with that on the earth, showing lines B to G, but the extreme lines with, I thought, less distinctness. At 4h. 30m. at the height of about one mile, the spectrum was bright, but less in length, both at the violet and red ends. The line G was quite the limit, and I could not see B, and C was doubtful. At 4h. 35m., at the height of about 2 miles, G was lost entirely, and the violet was dull; I could see F and D, but not beyond. At 4h. 42m., at 3 miles high, I lost violet entirely, and could not see F. At 4h. 46m., between 3 and 4 miles high, the spec-

trum was very short. I could see from a little beyond D to E, I think b, but not F. At 5h. 10m. at 4 miles high, I could not see any spectrum, excepting a little yellow tinge. At 5h. 30m. at 4½ miles high, I saw no spectrum and no color. At 5h. 43m., at the height of 3 miles, on descending there was no spectrum; I opened the slit and saw a faint tinge of color only.

Bearing in mind that the time available for this class of observations in the balloon is inadequate to take correct drawings, I only attended, with as much care as the shortness of the time admitted, to the general appearance, the limiting lines of visibility at both ends of the spectrum, and very little to the thickness, or number, or definition of the lines themselves. The general result is, that no lines were lost from the spectrum, excepting those by the shortening of the spectrum itself; but it must be borne in mind, that although it was very light with us, yet the sun was low, and the shortening of the spectrum itself may be attributable to the want of light. For this class of experiments, it will be necessary to have a balloon ascent starting either in the morning or about noon, to compare with the preceding observations, and to determine whether the spectrum does really shorten with elevation, as well as to determine whether any lines are lost by passing into a less dense atmosphere.

One of the principal subjects of research in the balloon experiments of last year was the determination of the law of decrease of temperature with increase of elevation. The results from my ascents last season were that when the sky was clear, a decline of 1 degree took place within 100 feet of the earth, whilst at the height of 30,000 feet a space of fully 1000 feet had to be passed for a change of 1 degree of temperature, and that between these limits a gradually increasing space was required for a change of temperature to the same amount, plainly indicating that the old theory of a decline of temperature of 1 degree for every 300 feet must be abandoned.

The previous ascents were made in the months of July, August, and September. It became of the highest importance to have similar experiments in the other months of the year, and the British Association at its meeting in Cambridge, voted £200 for experiments to be begun in the spring, and some of which, if possible, during the prevalence of east winds.

The balloon left the earth on March 31, from the crystal palace, at 4h. 16m. P. M., the temperature of the air being 50 degrees; at 4h. 25m. we were one mile high, with a temperature of 33½ degrees; the second mile was reached at 4h. 35m., with a temperature of 26 degrees; the third mile at 4h. 44m., when the temperature was 14 degrees; at 3¾ miles high the temperature was 8 degrees. A warm current of air was met with, and it rose to 12 degrees at 4h. 58m.; at 5h. 2m. we passed out of the current, and when 4½ miles high the temperature was just zero of Fahrenheit's scale.

In descending, the temperature increased to 11 degrees at about three miles high, at 5h. 38m.; then a cold current was met with, and it decreased to 7 degrees. We soon passed through it, and the tem-

perature increased to 18½ degrees at two miles high, to 25½ degrees at one mile, and to 42 degrees on the ground, which was reached at 6h. 30m.

When one mile high the deep roar of London was heard distinctly, and its murmuring noise reached us at a greater elevation. At heights of three and four miles high the view was indeed wonderful—the plan-like appearance of London and its suburbs; the map-like appearance of the country round; then running the eye down the winding Thames, to the white cliffs at Margate, and on to Dover, Brighton was seen, and the sea beyond, and all the coast line was clear up to Yarmouth. The north was obscured by clouds. Looking under us, and to the south, there were many detached cumuli clouds, resting apparently on the earth, like patches of shining wool, and in some places a solitary cloud thus apparently resting on the earth surrounded by a clear space for many miles.

Blackheath, April 6, 1863.

Scientific Balloon Ascent. By James Glaisher.

From the London Athenæum, No. 1852.

In the *Athenæum* of the 11th inst. are detailed the observations I made on the sky spectra in the Balloon Ascent on March 31. They were so different from what I expected that I could not avoid coming to the conclusion, that they were of little value in consequence of the ascent having been made so late in the day. I therefore resolved that the next ascent should be made when the sun was near the meridian, and that the spectrum examination should be a primary subject of investigation. The apparatus was the same as that used on the previous experiments. It was covered with black cloth to prevent any stray light falling on the prism, and whilst observing my head was also covered with black cloth. Between the hours of 11 A. M. and noon, I examined the solar and sky spectra with care. The sky was generally covered with cumuli, and there was a great mist. The solar spectrum extended from B to H nearly; and the sky spectrum from B to G, but these were quite its limiting lines.

We left the earth on April 18 at 1h. 17m. P. M.; within two minutes afterwards we were 3000 feet, and at 1h. 23m. we were one mile high. The second mile was passed at 1h. 29m.; the third at 1h. 37m.; the fourth at 2h.; and the highest point was reached at 2h. 30m.—at the height of four-and-a-half miles nearly. At 2h. 36m. we passed below four miles; the next mile downwards was passed at 2h. 40m.; and at 2h. 46m. we were two miles from the earth, which we reached at 2h. 50m. At 1h. 20m. looking close to the sun, the line G was very clear, as well as the two nebulous lines H, and the spectrum extended somewhat further; many lines were seen. At 1h. 21m. at the red end of the sky spectrum near the sun, the line B was very clear, and many lines between B and F were visible. At 1h. 28m. the sky spectrum under and close to the sun extended from A at the red end to beyond H; the lines were beautifully defined, and I thought somewhat more numerous

than as viewed from the earth. At 1h. 28½m. the sky spectrum at some little distance from the sun did not reach to G, and scarcely to B; but there were many lines between these extremes. At 1h. 33m. on directing the slit to the sky far from the sun, the field of view was dark. At 1h. 37m. as the balloon was revolving I had a beam of light from the sun, whilst looking at the red end, and all lines were clear up to A. At 1h. 39m. the slit was directed to a point in the sky as near the zenith as the balloon permitted, and the spectrum was very short, and no lines were visible; turning the telescope round so as to sweep the sky, from a high point to a low one, I lost the spectrum entirely; there was no light at all. I could not turn the telescope round sufficiently to direct the slit to the clouds beneath. From 1h. 47m. to 1h. 49m. I could not get the slit directed to the sun, but the sky was blue and bright, and I kept my eye at the telescope and looked intently, but there was no light. I became anxious and uneasy, lest from my confined and constrained position, I was not looking fairly through the telescope, or the slit had become out of order, or something had become deranged, as shortly before the apparatus had swung round with a lurch of the balloon. At 1h. 53m. I examined the eye piece, and cleaned it, for fear in my anxiety I had breathed upon it; I also examined the slit, and every part of the apparatus I could; all seemed to be right. At 1h. 56m. the field of view was quite dark, the slit being directed to the sky far from the sun. At 2h. 9m. and at 2h. 14m. the field of view was quite dark, when the slit was directed to the sky, the sun being nearly opposite. At 2h. 15m. I succeeded in getting a good adjustment upon the sun; and from this time till 2h. 31m., I devoted myself almost entirely to the examination of the spectrum; during this time we were from 4 to 4½ miles high. The balloon revolved once round in about five minutes, and I kept my eye at the telescope during the first revolution, and nearly so with the others. When the light came from the sun I confined myself at first to the violet end, which extended a good way beyond H, both of which were clear and made up of many fine lines. On passing from the sun, the spectrum shortened, and G was the limit; this was soon lost, and the spectrum shortened very rapidly, and there was none when looking opposite to the sun; on approaching the sun again, the spectrum again appeared. I directed my attention this time to the red end: B was visible on approaching the sun, and A became visible when a beam of light entered from the sun itself, and many lines were visible between A and a, and a and B; on passing from the sun the same phenomena were repeated as before; and when the sun again came round, I carefully examined the whole spectrum from A to a good way beyond H, sweeping the telescope up and down two or three times, and every line was visible that I had seen when looking at the sun from the earth before starting, and a great many more. The number of lines visible seemed to be innumerable. This experiment appears to be conclusive, and shows that sky spectra, viewed from above the clouds, are confined to the immediate vicinity of the sun itself, and indicates that the amount of light from the sky

is very small indeed. The number of lines in the solar spectrum appear to be increased when viewed from a position above the clouds, and therefore none of the lines as viewed from the earth would seem to be atmospheric.

Taking together the whole of the sky spectra, they agree with those of the preceding ascent, and confirm their accuracy.

After reaching the height of four miles, and we had determined we were moving directly towards the coast, Mr. Coxwell continually applied to me for the readings of the barometer, and directed our companion, Mr. I——, to keep a sharp look-out for the sea. Immediately after we attained an elevation of four-and-a-half miles Mr. Coxwell let off some gas, and said he felt assured there was not a moment to be lost in getting within view of the earth. He again let off gas rather freely, so that we descended a mile in four minutes. At 2h. 46m. we were two miles from the earth, the barometer reading 21·20 inches, when Mr. Coxwell catching sight of Beechy Head, exclaimed, "What's that?" and on seeing the coast through a break in the clouds, he again exclaimed, "There is not a moment to spare—we must descend rapidly, and save the land at all risks." It was a bold decision, but we were in a critical position, and I do not see what else could have been done.

When orders were given to put out sand we did so simultaneously, which gave a favorable check; and as the lower part of the balloon itself assumed a parachute form, the shock was not so bad as might have been expected. Most of the instruments were broken, owing to their delicate construction, and my attention being drawn from them, yet, strange to say, the glass vessels of air collected at the highest point for Prof. Tyndall remained uninjured, as did some bottles of lemonade which Mr. Coxwell had placed in the car.

We descended the last two miles in four minutes, and the descent was within half-a-mile of the station at Newhaven.

Blackheath, April 21st, 1863.

The New Art of Auto-typography. By George Wallis.

From the Journal of the Society of Arts, No. 543.

As the new art-process for the re-production of drawings to which I am about to call attention, and as far as possible describe and illustrate before you, is based in principle upon a process of an analogous character, by which certain classes of natural objects are engraved and printed, popularly known as Nature-Printing, I think it desirable, from my personal connexion with the two gentlemen who certainly originated the direct method of Nature-Engraving, as I prefer to call it, in this country, and my knowledge of their early efforts, to endeavor briefly to correct a wrong impression which I believe to have been unintentionally given, through an imperfect knowledge of the true facts and the dates at which the first experiments were made in England.

In a paper read at the Royal Institution, 11th May, 1855, by the late Mr. Henry Bradbury, to whose ability, energy, and perseverance,

the art of nature-printing owes so much, and also in a more recent publication, the early attempts to obtain impressions from plants, &c., are carefully traced up. In these papers Mr. H. Bradbury gives the credit, which is evidently due, to a Danish goldsmith and engraver, Peter Kyhl, of Copenhagen, as having been the first to produce impressions in metal plates direct from natural objects; but whilst honorably seeking to do justice to an ingenious man, who unfortunately died in 1833, the year in which he made his invention known, he does a certain measure of injustice to the late Mr. Richard Ford Sturges and Mr. W. C. Aitken, of Birmingham, on the assumption that the experiments made by the former in August, 1851, and the latter in the spring of 1852, were based upon a knowledge of what Peter Kyhl had done. I have no hesitation, therefore, cognizant as I am of nearly all the earlier efforts in this direction at Birmingham, to declare that neither Mr. R. F. Sturges nor Mr. W. C. Aitken knew any thing whatever of Kyhl or his experiments, and did not even know that such a person ever existed prior to the publication of the paper read by Mr. Henry Bradbury at the Royal Institution, more than three years after Mr. R. F. Sturges' patent for the ornamentation of metals by pressure, which process he claimed as his invention, had been taken out.

I have felt it my duty to state this, because I purpose bringing out the true dates in connexion with the invention of the process of Nature-Printing, leading as this process does to that which I am about to describe and illustrate, and of which I claim to be the inventor.

That the Danish goldsmith and engraver, Peter Kyhl, did, in the year 1833, exhibit at the Exhibition of Industry, held at Charlottenberg, various productions in silver, decorated by a process described in a manuscript, entitled "The description (with forty-six plates) of a Method to Copy Flat Objects of Nature and Art," dated 1st May, 1833, and that the plates "represented printed copies of leaves, of linen and woven stuffs, of laces, of feathers of birds, scales of fishes, and even serpent skins," we have the authority of the late Mr. Henry Bradbury, based on that of Professor Thiele, and therefore we may accept it as a fact; but that this fact had anything to do with the experiments instituted at Birmingham, in August, 1851, by Mr. R. F. Sturges, in the engraving of lace, and early in 1852, by Mr. W. C. Aitken, in engraving skeletons of leaves, feathers, &c., by placing the objects between two plates of metal and subjecting them to pressure by steel rolls, I emphatically deny. The truth is, Kyhl's process had been evidently forgotten, and his manuscript, buried in the archives of the library at Copenhagen, was not dug up until the Imperial Printing Establishment at Vienna had given dignity to the process of nature printing, and Mr. Henry Bradbury had brought the invention from Vienna, where it was practised, and, by his skill and ingenuity, had begun to produce the works which are so worthily associated with his name.

The facts are these. In August, 1851, the late Mr. R. F. Sturges made some experiments in direct engraving, by placing pieces of lace

between two Britannia metal plates, and passing them through a pair of steel rolls, revolving at a suitable pressure, his object being to devise some cheap and rapid process for the ornamentation of metal. A little specimen in one of the frames before you is an impression printed from one of the plates so engraved at this period. Mr. Sturges took out a patent for "ornamenting metallic surfaces," based upon the results he had arrived at. This patent is dated 24th January, 1852. [Patent No. 13,914.] Specimens were shown about as curiosities, especially impressions printed from the plates. In assisting to bring this patent into operation, in the establishment of Messrs. R. W. Winfield and Son, Cambridge-street Works, Birmingham, Mr. W. C. Aitken made his first experiment on natural objects with a skeleton leaf, picked out of a roadside brook, early in the spring of 1852. An impression of this, together with one of the two plates, which Mr. Aitken presented to me, are now before you. This result was shown to me in a day or two after it was produced; therefore, I am speaking from experience, and not from hearsay, or upon any authority. Mr. Aitken subsequently brought the further results of his experiments before the Society, in a paper read in February, 1854, and printed in the *Society of Arts Journal*, vol. ii. p. 227

In Mr. Henry Bradbury's paper, read at the Royal Institution, he says, "In the Imperial Printing-Office at Vienna, the first application of taking impressions of lace in plates of metal by means of metal rollers, took place in the month of May, 1852. It originated in the Minister of the Interior, Baumgartner, having received specimens from London, which so much attracted the attention of the Chief Director, that he determined to produce others like them." Now we all know what the Imperial Printing-Office of Vienna showed in the Great Exhibition of 1851; and, beautiful, and even wonderful, as the specimens were, that there was nothing in any way approaching to nature printing. The Austrian Commission, however, was busily employed in London until the end of 1851 or beginning of 1852. Its members visited Birmingham, as our foreign friends usually do on these occasions, as a relaxation from heavy duties, and from a laudable desire to obtain information.

Mr. R. F. Sturges was not a man to "hide his light under a bushel," and therefore I have little doubt that the specimens of impressions of lace from plates engraved by him were sent to the Austrian Minister of the Interior, being obtained, either directly or indirectly, from Mr. Sturges immediately after he had secured himself in England by patent. If not, where did they come from? No one else in this country had at this period done any thing of the kind. Peter Kyhl had been dead and his experiments at Copenhagen forgotten, where alone they had been known, eighteen years before.

If we compare the date of Mr. R. F. Sturges' patent, January 24th, 1852, with the date given by Mr. H. Bradbury, May in the same year, as the period of the first experiments at the Imperial Printing-Office at Vienna, it will be seen at once that Mr. Sturges had no ob-

ject in the concealment of his process, or its results, for three months before any thing was known or done at Vienna.

In making these remarks, I do so for the honor of Birmingham, and from a strong conviction, based on a personal knowledge of the facts, and not from hearsay, that the action of the Imperial Printing-Office at Vienna, was induced by the successful experiments made in Birmingham in 1851–52.

Having thus, as an act of justice to an ingenious manufacturer, stated these facts as to the independent re-invention, at least, of this process, assuming Peter Kyhl's to have slept—as it really did—not only from 1833 to 1851, but, in fact, to 1855, when it was brought forward through the instrumentality of Professor Thiele, I may now briefly allude to the several processes employed for the re-production of flat natural objects by means of metal plates and the printing press: the nature printing of Dr. Dresser by transfer from leaves of plants, &c., to paper direct, and his process of transfer to lithographic stones and printing therefrom, being outside the present question, although very interesting and useful in many points.

In 1847, Dr. Branson, of Sheffield, made a series of experiments, commencing with taking impressions of leaves in gutta percha, from which he cast a brass mould to print from. An electrotype plate could also be obtained. In 1851, Dr. Branson brought this interesting subject and his processes before the Society of Arts.

After the Imperial Printing-Office at Vienna had experimented upon lace, &c., in 1852, as already mentioned, we have Mr. Henry Bradbury's authority for stating that gutta percha was tried by Andrew Worring, in whose name the patent was subsequently taken out. No doubt this plan was derived from Dr. Branson. This failing, he, says Mr. Bradbury, "employed," as Peter Kyhl had done before him, "soft lead plates." Yet, probably, Worring was as innocent of any knowledge of Kyhl's doings as Mr. Sturges was. This Mr. H. Bradbury acknowledges with regard to the former, and it is deeply to be regretted that he did not do so in regard to the latter, as I think that Worring, being connected with such an establishment as the Imperial Printing-Office at Vienna, was much more likely to know of the existence of Peter Kyhl's manuscript in the Royal Library at Copenhagen, than a busy manufacturer at Birmingham. Mr. Henry Bradbury's process was taken from that practised at the Imperial Printing-Office at Vienna, where he was engaged for a period, with such improvements as his great ingenuity and perseverance enabled him to introduce; and we see the result in the magnificent volumes published by Messrs Bradbury and Evans.

In all these processes, however, the plate from which the impressions had to be printed, was an electrotype copy of the soft lead plate in which the object was engraved, and a considerable amount of labor and skill in burnishing and touching up had to be expended before the plate was fit to yield a satisfactory impression.

This is not the case with the direct process, or with Mr. R. F. Sturges' method of copying lace, &c., and more particularly as carried out

in reference to natural objects by Mr. W. C. Aitken. The impressions of the most delicate skeleton of a leaf, or a feather with its down, are impressed direct in all their delicacy, and the plate is ready to print from at once.

It was this fact which led me to the experiments which have resulted in the process I am now to describe, for on seeing the first specimen of a feather engraved by Mr. W. C. Aitken, early in 1852, I asked myself mentally, "If the down of a feather can be made to impress itself in a metal plate, and print, why not a drawing?" The next question was, "How to do it?" Urgent duties prevented any experiments until the winter of 1858. The result of these experiments I shall now give in detail.

No want has been more strongly felt in the arts than some easy, rapid, and direct method by which the spirit and mental impress of the artist's own hand could be re-produced in a metal plate, or type, either in intaglio or relievo. I remember reading, when a youth, in some old edition of the Life of Albert Durer, that he had solved this problem, and had a secret method, which died with him, by which he could transfer a drawing to a metal type and print from it. Whether this was simply a mystical description, by some person ignorant of art-processes, of the ordinary method of etching, in which Durer was such an adept, I cannot say, but it made a deep impression on my mind, and the question how to bring about such a result was for years a subject of interest and speculation with myself, as it has no doubt been to hundreds of others. When, in 1842, Mr. Palmer commenced his experiments in glyphography, some friend, knowing my propensity to experiment in this direction, sent him to me, and I believe I executed for him the first drawing produced by his process, in which lines were drawn in imitation of etching, or the *fac-simile* style of wood engraving. After several experiments, however, not seeing my way to satisfactory artistic results, I declined to devote any more time to this process. I have ventured to name this as showing that my attention was by no means first drawn practically to this question, when the success of the direct nature engraving of my friend, Mr. W. C. Aitken, in 1852, directed it into a new channel. In fact, every process of the kind had been practically examined and tested—etching on copper and steel, lithography, zincography, the anastatic process, the paneiconography of Gillot, shown in the Exhibition of 1851, from which so much was expected in surface printing, had all had attention. The matter was, therefore, not taken up blindly, except in one point, and that a most important one, for every single step of the solution of the problem had to be taken practically in the dark, as there was no experience in the same direction to suggest, still less to guide, in a single experiment; and even now, after four or five years' experience, I rarely make an experiment without gaining some additional light, which either helps the certainty or extends the operation of the process. I beg, therefore, most distinctly to state, that I do not bring this before you as a perfected process, but simply as a method which, so far as experience has gone, has produced certain undeniable artis-

tic results, and as containing, as I believe it does, the elements of far higher, much wider, and more practical issues in the future. I trust no one will tell me that because the effects shown on this occasion are only produced in *intaglio*, that it would be much better for economical purposes to produce them in *relievo*, and thus suit them to the immense demand for surface printed illustrations. Of all this I am quite aware; but having so far accomplished one phase of the invention and undertaken to explain it, I shall confine myself to that. Should I, having already made a beginning, solve the other part of the problem, and produce a block where I now only produce a plate, I shall ask for another opportunity to bring that before you in due course. In the meantime our subject is the production of a metal plate engraved direct from a drawing and suitable to be printed from at an ordinary copper-plate printing-press, or for transfers in certain industrial arts.

There are several methods by which the drawings can be made, but I shall confine my attention to describing and illustrating those which have been most successful up to this time. The material may be paper of suitable texture, such as fine India post, or sheet gelatine, or the drawing may be made on the surface of the plate to be engraved, or on the plate-glass bed of the machine.

When a drawing is made on paper there is a choice of two methods. One is to make the drawing with a glutinous ink, which, when apparently dry, will, by floating it upon the surface of water, or damping equally at the back, become so far wet again as to take up fine particles of emery or other hard granular substances reduced to a powder. The effects produced are bold and effective, but rather coarse, as the examples shown indicate. The other method is to make the drawing with the same material as that used in executing a drawing on sheet gelatine, on the plate, or the plate-glass bed of the machine.

These drawings on paper when engraved, produce a tint all over the subject, the result of the texture of the paper itself. This tint may be very usefully employed in producing gradations of tone, when treated with a mezzotinto scraper and burnisher.

The material for executing the drawings on sheet gelatine, &c., presented the greatest difficulty, and cost some hundreds of experiments. It is composed of peroxide of tin, peroxide of manganese, Indian or Venetian red, Paris white, rice starch, gum arabic, and bichromate of ammonia, the latter being used for the purpose of converting the gum and starch into an insoluble resin, so as to permit of the repetition of the touches of the drawing, without disturbing the work previously executed. The relative proportions of the ingredients of this drawing material, which requires special care and experience in its preparation, are given in the specification of the patent, [No. 1299, 1860,] by which the invention has been secured, and therefore need not be quoted here, as, of course, modifications are made for the purpose of producing special effects, of which the practice of the art can alone show the use.

This drawing material is classified for use as No. 1, with which the outline and basis of the drawing is executed; No. 2, which is darker

in color, is used to re-touch parts requiring greater force than that produced by No. 1; No. 3 is sometimes used for producing very strong granular effects in the shadows, but generally I think it best to avoid its use.

One great peculiarity of this process is the production in the metal plate of the effects produced by broad washes and touches executed with a brush, somewhat of the character of aquatint. These broad effects are produced in the drawing by the washes being thrown in after the simple outline of the subject is obtained with material No. 1, by means of a special material, which, for convenience, is called Tint A, to indicate its use. A more granular modification of this mixture, Tint B, is used to obtain greater force in such parts of the washes as the artist may deem desirable.

The drawing instruments used are pens, metallic or otherwise, of suitable quality as regards fineness or breadth of point, and the ordinary sable brushes used in water-color drawing.

When a drawing has to be executed, say on sheet gelatine, the material is selected of as even thickness as possible, and with the surface upon which the drawing is to be made free from spots, bubbles, or other blemishes, as these will come in contact with the plate during the operation of engraving, and all defects will be re-produced as well as the artist's work. The piece of sheet gelatine is mounted in a card board mount, the "sight" being cut to the size of the plate in which the drawing is to be engraved. [A specimen properly mounted was shown.] Over the back is placed a piece of tissue paper, fastened only on one side, so that it can be turned back, while the subject is traced upon the gelatine with the drawing material No. 1, from a study prepared for the purpose, and as the gelatine is as transparent as glass, of course, this tracing can be done with the greatest nicety. The outline being secured, the piece of tissue paper is then returned to its position, and the drawing has much the appearance, when looked through, of being executed on ground glass.

To facilitate easy execution I have invented a drawing desk with a glass top fixed in a frame. This can be placed at any convenient angle, and by this disc being placed so that the artist can sit opposite to the light, with a piece of white paper on the bottom of the desk under the glass, the light is thrown through the partly executed drawing, and every facility is thus given for finishing it with all the force and effect of which the process is susceptible. [A specimen of the desk was shown in use with a lamp.]

The drawing materials, being in the condition of powder, are mixed for use by taking a small quantity of the gradation required and adding to it sufficient water to make it flow easily and continuously from the pen. If used too thin, however, the lines produced in the engraving are not forcible, and the principle of the invention must then be carefully borne in mind, viz: that the lines will engrave in proportion to their substance, just as the natural object engraves according to the thickness and density of its substance. In this fact lies the whole condition of a successful drawing, and perhaps I could not give a better

illustration than by reminding the artist that, as in oil painting, the impasto, or loaded portion of the drawing is in the lights, the reverse is the case in auto-typography, for the deeper the shadow required the higher the relief of the drawing material should be off the surface of the drawing, as the greater will be the intaglio thus produced in the plate. Of course it would be hopeless to attempt to give precise rules for producing special effects. We are dealing with an art, and to know it, it must be practised; and I believe that it has this merit, that the impress of the mind and manual dexterity of the artist will add to the great charm of the results produced, whilst the limit, under certain conditions, is simply that of the ingenuity and skill of the executant.

The drawing being ready for engraving, which it is as soon as dry —that is, a few minutes after it is finished, although as a rule it is better to let it stand for a few hours—it is taken to the machine.

The machine now before you is a working model of improvements suggested by the experience gained in the construction of one four times the size, and by which the largest specimens have been produced. This consists essentially of a pair of rolls mounted on horizontal axes. The bearings of the lower roll are fixed, whilst the brasses of the upper roll in which it turns are capable of a vertical sliding motion in the side standards. By means of side screws and hand wheels the upper roll is raised or depressed. In this small machine the wheels are engraved with gradual degrees for the indices of pressure, which can be regulated to the 1520th of an inch by the usual relation between the rotation of the index wheels and the thread of the screws. The edges of these wheels are notched or toothed in correspondence with the graduated degrees, and a fixed index with a spring engages as the wheels are moved, thus indicating both the pressure and parallelism of the upper roll with the lower. Between the two rolls a horizontal table or bed, which is supported by steel spring bars, is made to slide. The table may be made entirely of metal, but in this instance it is made of steel, with a well, into which a piece of plate glass is fitted and securely embedded upon a sheet of gutta percha. The plate glass possesses great advantages over metal, both as regards surface and non-oxydization, whilst the facility with which it can be removed, when required, from the well or metal frame for convenience in drawing upon is of great importance.

The rolls are made to revolve by means of a worm-wheel attached to the axis of the lower roll, but working outside the frame-work. Motion is communicated by a worm which drives the wheel, the power being applied to a hand-wheel or winch attached to the lower end of the worm axis or shaft, which works within a bearing and hanging bracket attached to the frame of the machine. The rotation of this shaft and worm communicates a slow and steady motion to the lower roll, and as this is geared on the opposite side to the upper roll by means of toothed wheels, the rolls rotate simultaneously.

The method by which a plate is engraved has now to be described. The thickness of the plate being gauged by one of Whitworth's decimal gauges, the indices are turned to the particular degree indicated

by that thickness, with the allowance of the 50th of an inch, and the thickness of the gelatine, which may be calculated at another 50th, as engraving pressure. It should be borne in mind, however, that the gelatine is elastic and yields probably full one-half its thickness, so that the *plus* pressure beyond the gauge of the plate may be taken at about the 30th of an inch.

The metal plates used are a good quality of Britannia metal, and, so far as experience goes, these print a fair number; but by taking advantage of Joubert's process for steeling the surface, or producing an analogous effect by means of nickel, the plates yield a considerable number of impressions; and as the drawing is comparatively uninjured by the process, several plates of the same subject can be produced from one drawing by a careful examination of it, and a little retouching in such parts as may appear worn or deteriorated by the pressure in the operation of engraving. In some instances as many as six plates have been produced from one drawing, and it is still available, and, unless injured by damp or some accidental cause, will be available for years to come.

It will be evident, from the nature of the process, that it possesses several advantages over any other in use for the re-production of the artist's work direct from his own hand. Thus:—

1. There is no reversal of the subject required, as it is drawn exactly as it is to appear when printed.

2. A plate can be engraved and proved to show the state of the drawing. The latter can be worked in again, and again proved, and this can be repeated until the desired effect within the limits of the process is produced.

3. The transparency of the sheet gelatine gives great facility for copying drawings by tracing all the leading features; and, of course, this applies to photographs, which may be largely used as guides, and art thus made to supplement science, since the artist has the power of selection in re-production of the forms of the photograph by auto-typography.

4. The rapidity with which designs, drawings, &c., may be re-produced, when they are once executed by the auto-typographic process, which, as already stated, becomes with a slight degree of practice, as easy as ordinary sepia or Indian ink drawing.

5. The fact that the artist can retain the plate in his possession, and have such a quantity printed at a time as may best suit his convenience, as in the case of an etched plate.

In all the illustrations given it must be distinctly understood, that no after process, or any re-touching whatever, has been used. All the examples are the result of the auto-typographic process, pure and simple. It must be quite clear, however, that some of the effects could be rendered much more positive and telling by judicious touching up with the graver and etching needle. As, however, it would have been difficult to have defined where the process which is the subject of this paper ended, and that of touching up began, it was thought desirable that none should be shown which had been so treated. It must be clear,

however, that for practical purposes, those well known means of increasing the force of an engraved plate would be largely available when required.

There are only two points now to consider, and this paper may be brought to its conclusion.

The first is—Can the process be regarded as complete? To this I answer, as the inventor, that so far as the effects already attempted are conceived it may be, but I feel satisfied that in the hands of an ingenious artist, fertile in resources as regards the production of delicate and even powerful effects, it is susceptible of very great development. This, however, depends upon one point, to which I am particularly desirous to have attention paid on this occasion in any remarks which may follow this paper, and that is, whether in the present advanced condition of the art of illustrative printing in its varied forms, this process is worthy of special attention and further development.

The second point is the purposes to which, if this question is settled in the affirmative, the process can be artistically and economically applied. Under the latter head we may range the production of artists' sketches at a comparatively cheap rate, the plate being held for use at any period subsequent to the re-production; also plates for book illustrations and the production of portraits in a metal plate by the aid of a photograph, the auto-typographic drawing being worked upon from life if necessary. The portraits so produced are, of course, as permanent as those printed from ordinary engraved plates. In the industrial arts, the production of transfer plates, especially for the "bat" process for the decoration of porcelain, appears to afford a considerable field of operation, as the drawing produced by the original artist is re-produced on the ware; and outlines drawn by a first-class artist may be transferred to the surface of an article in porcelain, to be filled in with color by the artist workmen, whose technical knowledge is thus used to the greatest advantage. It must be evident, too, that metallic surfaces being planes, may be decorated in a novel and effective manner by painting upon the metal plate the design intended to be engraved, and then submitting it to the action of the machine. Results may be thus obtained which no engraving with a point could possibly achieve, and these effects may be further enhanced by working upon with the graver.

Of course it is impossible to calculate what ingenious persons may make of any invention at the outset. Experience has shown that the most unpromising in the beginning have come out triumphantly in the end; and it is equally true that many processes of apparently great value and probable usefulness when first developed, have sunk into oblivion before the test of practical and every-day application. Whether the process I have brought before the Society of Arts in this paper belongs to the one category or the other, it would be presumptuous to pronounce too distinctly in its present stage. I may be allowed however to state, in concluding this description of its purpose and leading features, that the main object I have had in view in following up a series of experiments extending over more than four years, at no

little cost of time and money, has been the improvement of the arts of my country, both pictorial and industrial, by bringing the artist himself nearer to the re-production of his own work, and affording a means by which the impress of the original mind and hand shall be conveyed in a permanent form, for easy re-production in considerable numbers, at a comparatively cheap rate.

As a matter of interest to the members of the Society of Arts, I think it a duty, as it certainly is a pleasure, however largely mixed with sorrow, for me to state, that the late lamented President of the Society, His Royal Highness the Prince Consort, expressed a very distinct and favorable opinion of the process in its application to various branches of art when specimens were submitted to him, and a desire to know more of the practical working than could be given by mere description; but his premature removal from his earthly sphere of usefulness, prevented the fulfilment of arrangements proposed for meeting his wishes. We all know the intelligent interest with which he invariably investigated all matters which seemed worthy of attention, or likely to prove useful to the arts and sciences of his adopted country, and his readiness to encourage, by kindly words and judicious advice, efforts which he believed to be in the right direction. To myself, although greatly encouraged by the favorable opinion expressed, it would have been a source of infinite satisfaction to have submitted the whole process to the judgment of one so able to appreciate its value on the one hand, or detect its defects on the other.

On Luminous Meteors. By Mr. Herschel.

[From a Discourse before the Royal Institution, April 24, 1863.]

From the London Athenæum, No. 1854.

The term includes fireballs, shooting-stars, and aërolites. Lightning in the lower air presents no analogy to the phenomena of fireballs. Were the occurrence of globe lightning sufficiently proved and its origin explained, it would be contrary to analogy to infer a similar origin for meteors. The height of fireballs has been known since the time of Montanari in Italy, and Wallis in England, in 1676, and was calculated by Halley in 1714 and 1719, and again by Pringle in 1758. The calculation of eleven large fireballs most recently reported to the British Association, as passing over England during the years 1861–63, shows their first appearance to be at the heights from 30 to 196 miles above the earth, and their points of disappearance from 15 to 65 miles above the earth. Their velocities are from 23 to 60 miles per second. In illuminating power they resembled globes of inflamed coal-gas, from 14 to 50 feet in diameter. In many fireballs a ball of bluish light alone is seen, and this has been explained by Mr. Brayley and Dr. Haidinger to be air heated by compression, as in a fire-syringe, before a parcel of solid matter entering the air with immense velocity from planetary space. The heat of the flame, as in the oxyhydrogen lime-light, produces intense light by volatilizing the solid materials of the aërolite. Mr. Herschel suggested that the same heat might dissociate

the oxides of the meteoric surface, and by lining the track with mixed blast and fuel of a spontaneously inflammable nature, cause the sparks and tufts of ruddy light and the phosphorescent streaks which occasionally endure for many minutes or even for an hour after the passage of a meteor. In illustration of this phenomenon, the phosphorescence of sulphurous acid was exhibited, when a luminous current of electricity through the gas was suddenly stopped. The storm of stars occasionally seen in great magnificence on the mornings of the 13th of November was first shown to be periodic by Prof. Denison Olmsted in America in 1836; but the more constant shower in the evenings of August the 10th was pointed out in England by Mr. T. M. Forster in 1827 by the publication of a MS. calendar of the last century, preserved at Corpus Christi College, Cambridge, where that day and the 18th of August are called by the writer (probably a monk) "stellibund" and "meteorode." M. Quetelet, at Brussels, in 1836, and Prof. Herrick, at New Haven (U. S.), aware of the unconcealed periodicity of the November shower, pointed independently to the second week of August as an epoch of annual return; and the diligent researches of Prof. Herrick proved the 10th to have been uniformly remarkable for shooting-stars during a long course of years in the last century and this. Four observations from two different stations determine the path of a single shooting-star, and their heights and velocities were so determined by Brandes and Benzenberg, at Göttingen, in 1798. Such observations were originally proposed to the Royal Society of England by J. Lynn, Esq., in 1727, and have been repeated, since the time of Benzenberg, by Quetelet, at Brussels, in 1824, and later, by Prof. Heis, at Aix-la-Chapelle, Bessel, Feldt, Erman, Schmidt, Secchi, and other continental astronomers. The heights and velocities of shooting-stars are quite similar to those of fireballs, and, like those, descending downwards towards the earth. Like shadows from a straight candle-shade, the parallel streams of meteor showers appear to radiate from a fixed point among the stars. In November the radiant point rises at midnight, but in August it belongs to the circumpolar heavens. Like fireballs, shooting-stars are therefore, probably, asteroids or minute morsels revolving in zones about the sun. The most remarkable meteors are aërolites and aërosiderites, stones and iron masses precipitated from the air. A fireball always precedes these occurrences, and a report or detonation, some minutes before the stones precipitate themselves with thundering noise upon the earth. Specimens from 111 such catastrophes are exhibited at the British Museum, and 79 specimens of iron masses of similar origin. The stones are small, clay-like or tuffaceous blocks, of one to a hundred pounds or more in weight, inclosing grains and crystals of volcanic minerals, and particles of metallic and pyritic iron alloyed with nickel, and glazed with a thin enamel-like crust of the molten substance, proving their momentary exposure to flame of very intense heat since the fragments were broken from their native rocks and hurled against the earth. They are picked up too hot to be handled. They have an exceedingly uniform specific gravity, and agree in the presence of iron, nickel, and phosphorus in

their composition. Von Schreibers, at the fall of Staunern, ascribed to the stones a four-sided or three-sided pyramidal figure, but this has not been substantiated by more recent falls. Widmanstätten perceived upon the polished surfaces of the irons, etched with acid, the crystalline figures which bear his name, and most recently the structure of the stones has been examined by microscopic sections of their substance as well as by chemical and crystallographical descriptions of the parts. In illustration of the history of these stones, Prof. Tyndall exhibited upon the white screen numerous thin sections of their substance, prepared by Prof. Maskelyne, at the British Museum, for the microscope. A lunar-volcanic, or "lunar-ballistic," theory has been proposed for their origin from their common specific gravity most nearly equal to that of the moon, and from the scarcity of free oxygen which their composition betrays. But their high velocity renders a planetary, asteroidal motion round the sun more probably the native path in which they are intercepted by the earth. To illustrate the phenomena of the aurora, brilliant-colored discharges of electricity were passed through exhausted glass tubes and cells, when the transporting power of the magnet upon these currents was shown by their curvature and rotation about the magnetic poles. Observers were requested to communicate their observations of fireballs freely to the British Association, in the hope of deciding before long the laws of their return.

The Protection of Iron from Oxidation and Fouling.

By W. J. Hay, F. C. S., Assoc. I. N. A.,

(Read at the Institution of Naval Architects.)

From the Lond. Civ. Eng. and Arch. Journal, June, 1863.

The author remarked that a few years back the disadvantages arising from the oxidation and fouling of iron, and the consequent necessity for docking, as well as a loss of speed, almost led to a determination on the part of the Admiralty to discontinue the construction of iron sea going ships. But at a time when the executive were debating about the sale of the whole of the iron ships, the results of several experiments became known. A preparation of oxide of copper had been tried upon the *Undine* and several other vessels, and answered so well that the Government decided upon retaining those iron vessels which they had not sold. The author had tried many experiments that had occurred to him, but none stood the required tests so well as oxide of copper. An experiment was tried on the *Rocket* in May, 1845. On examination the results were found so satisfactory that at the suggestion of Admiral Sir Hyde Parker, she was coated in June, 1847, with alternate stripes of red lead and copper composition, and when docked about the middle of 1848, she presented a curious appearance, many of the red lead patches being corroded and having weeds 3 or 4 feet long; while the patches of composition were generally covered with a little slime, but there was neither weed nor corrosion on them.

A second experiment was made in September 1845, on H. M. yacht

Fairy. Three different kinds of composition were then tried. With reference to the first two, one by a Mr. Owen, and the other by Baron Wetterstedt, oxidation had gone on very rapidly, while with the third, which consisted of a composition of pitch, naphtha, and copper oxide, chemically prepared by the author, no oxidation had taken place, and the only defect perceived in it was a partial flaking off, occasioned by its being put on the bottom while in a wet state.

Another experiment was tried on H. M. ship *Recruit*, in April, 1847. The copper oxide preparation was put on the port side, and burned linseed oil and red lead on the starboard side, excepting a space amidships 4 feet square, to which the oxide of copper preparation was applied. On her return from the Tagus, the port side was found to have no adhesion, except about one dozen small barnacles; while the starboard side, excepting the space 4 feet square, was covered with bushels of the *Lepus anatifera*, or duck-barnacles. Of all the various compositions tried, oxide of copper had up to the present time been unequaled as a protector of the iron.

The next best materials for protecting iron were the water-proof glue, and a varnish of foreign asphalte and mineral pitch dissolved in rectified naphtha, but these required great attention to the quality of materials, and also to the application of them. The basis of the anti-fouling preparation, which had for years past been used in H. M. service upon the author's recommendation, was sub-oxide of copper. The oxides of copper used for this purpose were the scales separated from sheets of copper in the "pickling" process. These scales, after being pulverized, were mixed with a varnish made of vegetable pitch and rectified naphtha. The author wished it understood that the protective coating, when used with the oxide of copper anti-fouling composition, was not intended merely to act as a non-conducting medium to prevent galvanic action, but to protect the iron from chemical action resulting from the action of air and sea-water on the iron. It appeared to him that this action was little understood, judging from printed statements which occasionally appeared, and which attributed the loss and corrosion of iron to galvanic action of copper preparations. The copper oxide paint could not act as a galvanic agent, as every particle of oxide of copper was insulated by the oil or varnish in which it was enveloped, and unlike preparations of a metallic character, which had been frequently tried, and required oxidation previous to combination with chloric acid, the oxide of copper was, as soon as uninsulated, ready for chemical combination with the elements of the sea-water. The author admitted that one great difficulty had existed since the first use of copper oxide—that of requiring careful supervision in its application, for when the varnish was made too thick it became locked up, and much of its usefulness was destroyed in not coming in contact with the sea-water; and, on the other hand, when the varnish was made too thin, the oxide sank to the bottom, and, if the mixture were not continually stirred, it got left there, and did not reach the ship. He had now, however, he stated, succeeded completely in suspending the copper oxide during its application. He takes the puce-colored or sub-

oxide of copper, and roasts it, till it takes up another equivalent of oxygen and is converted into black oxide. This is then boiled with linseed oil until it assumes its original pure color as sub-oxide; the oil so treated becomes a quick drying oil, and is capable of suspending a large amount of copper oxide.

In his plans for the anti-fouling composition, the author included the application of zinc plates inside and outside the hull of the ship to prevent oxidation from abrasion or other causes. There were numerous parts of iron ships of war which required chemical supervision, as not only should every metallic fitting electro-negative to the irons be insulated, but every piece of timber should be insulated, especially in the bilge; for when wood decayed in contact with iron and sea-water, it produced sulphuretted hydrogen. Certain woods, however, were less liable to decay than others when in contact with iron, and among them were teak and stinkwood. In conclusion, the author alluded to the statements made respecting the foulness of the *Warrior's* bottom. He said that after she had been out of dock nine months she had no oxidation whatever on her bottom, although she was coated with the greatest expedition, it being then thought that her presence would be required in American waters.

Strength of Cast Iron Columns.

From the Practical Mechanic's Journal, June, 1863.

In an investigation on the strength of materials, Prof. Wiebe, of Berlin, is said to have arrived theoretically at the conclusion, that a solid round cast iron column is *weaker* than a solid round wrought iron one of the same dimensions; but a solid square cast iron column is *stronger* than a solid square wrought iron column of the same dimensions. Taken in all its generality, we doubt the possibility of such a result being correct.

On the Strength of Malleable Cast Iron. By M. Tresca.

From the Practical Mechanic's Journal, June, 1863.

The malleable cast iron of M. Dalifol, of Paris, is made from mixed Scotch pig, and the tempering is effected by the castings being inclosed in crucibles filled with native iron oxide, and exposed to a very great heat. Experiments were made with four square bars, of from ·6 to ·81 metres length, and about 1, 4, 9, and 16 square centimetres sectional area, which were supported at the ends on sharp edges, and loaded in the middle. The smallest bar, ·39 of an inch square (⅝ths full), and 1·87 feet long between the supports, showed, up to a load of 78 lbs., a regular increase in deflection of ·0973 inch for every 23 lbs., which gives a modulus of elasticity of about 12,600,000, the same as many good qualities of iron. The second bar gave a modulus of elasticity of 11,000,000; the third, 10,600,000; and the fourth, 10,800,000. Out of this last bar, 1·56 inches square was cut a fifth, only ·351 inch square: this piece was quite converted to the core, and gave a modulus of elasticity of 11,050,000; whereas a sixth bar cut out of the same

piece as the former, and being ·585 inch square, gave 9,860,000 as modulus of elasticity (equal to that of good cast iron). This shows that the iron is not wholly converted into malleable iron. A bar ·195 inch square, showed a tensile strength of 50,600 lbs. per square inch, nearly as much as good bar iron.

Gauging of Water by Triangular Notches. By W. YEATES, C.E.

From the Civ. Eng. and Arch. Jour., June, 1863.

I was interested by the paper in the last number of your Journal, entitled "Experiments on Gauging of Water by Triangular Notches." On referring to page 361, vol. xxiv. of your Journal, there referred to, I observed that seven inches was the greatest depth on the notch in the angle; and that the only triangular notches experimented with were a right-angled triangle and a triangle with slopes of two to one. It appears to me that these experiments were too limited, and only of value as far as they go. Unless for admeasurement of small quantities of water, the triangular notch appears quite unfit for practical application, and any inferences made for long triangular notches from rectangular ones, of little practical value. Why not at once use the rectangular ones, on which the experiments are most extended? On looking at Mr. Neville's hydraulic formulæ and valuable collection of experiments, I find at page 55, second edition, that using the co-efficient ·617, his formulæ for triangular notches become, when reduced for a right-angled notch $D = \cdot 317\, h^{\frac{5}{2}}$, which corresponds with that given in the Journal; and he has pointed out the general approximate application of the co-efficient ·617 to all sorts of orifices in thin plates, whether at the surface, as notches, or as submerged orifices, triangular, circular, polygonal, or mixed. The discovery of one general co-efficient of this kind is of great practical value, and supersedes any necessity for further experiments with small notches in thin plates.

Liverpool, May, 1863.

For the Journal of the Franklin Institute.

Vanderlyn the Artist and the Commissioner of Patents; or the Fine Arts versus *the Mechanic Arts.*

Shortly after the death of President Taylor, I spent an evening in Washington with Vanderlyn and the then Commissioner of Patents, at the house of a mutual friend. A portrait of the deceased President by V. had that day been disposed of by raffle. After expatiating awhile on Art and High Art, and giving incidents connected with the production of his famous pictures of Marius, Ariadne, Danae, Landing of Columbus, &c., the conversation slid into an amusing debate on the relative importance of the Mechanic and the Fine Arts, and on the social position of their professors. Vanderlyn was insulted at the comparison, and poured out scalding remarks on the ignorance and presumption that would raise the anvil and forge to a level with the pal-

lette and brush. The Commissioner laughingly replied that his position justified, if it did not require him to uphold the dignity of mechanical professions. "Mechanicians and Academicians," he said, "are both children of inspiration, and differ only in the media of its manifestations. One portrays his conceptions on canvass; the other casts them in iron and brass, and places the things themselves instead of their pictures before you. Is the genius that develops a steamship not equal to him who produced the Elgin marbles? Had the old Greeks, whom you worship, Mr. Vanderlyn, honored the Mechanic Arts more, and those which ministered to the vanity of their leaders less, they had left a brighter history. Some of their great thinkers were, however, sensible of the error, and have left a memorable proof of their conviction." "What is that?" exclaimed Vanderlyn. "Why this: Instead of awarding the goddess of Beauty to the patron of the Fine Arts, they gave her, you know, to a Blacksmith; and, as if to mark the moral with the keenest emphasis, to a homely, awkward, and a limping one! Such a decision may offend painters and sculptors, proud of their profession; but there is no getting over the fact that, on the sole ground of mechanical skill, an artizan, deformed, halting on a broken leg, his face and breast blackened with smoke, and his hands hardening into horn, is represented as bearing off the great prize in the face of the handsome and all-accomplished Apollo himself."

There was no reviving Vanderlyn's good humor after this; nor would he offer any other reading of the riddle. E.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, June 18, 1863.

John Agnew, Vice President, in the Chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society, London; the K. K. Geologischen Reichsanstalt, and the Nieder-Osterreichischen Gewerbe-Vereines, Vienna, Austria; l'Ecole des Mines, Paris, and the Société Industrielle de Mulhouse, France; Major L. A. Huguet-Latour, Montreal, Canada; Frederick Emmerick, Esq., Washington, D. C.; the Mercantile Library Association, Brooklyn, New York; Prof. John F. Frazer and Prof. John C. Cresson, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer's statement of the receipts and payments for the month of May was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (5) were proposed, and the candidate (1) proposed at the last meeting was duly elected.

Mr. Samuel Comly exhibited a patent Shaft Coupling, invented by Nathaniel Richardson, of Byberry, 23d Ward, Philadelphia.

The usual mode of attaching shafts to carriages has been by means of a screw-bolt and nut, in which there has been much difficulty in preventing the nut from working loose and dropping off in the continual jarring of the carriage. Mr. Richardson has very successfully obviated this difficulty by dispensing with the nut altogether, and by means of a very neat attachment keeps the bolt to its place by a spring, so arranged that its end rests against the head of the bolt, as will be seen in the accompanying engraving:

The spring B is attached to the back of the shackle at C by two small screws and nuts, parallel with and directly against the axle, about 3 inches, then turns and comes back to the head of the bolt, which is countersunk to receive it, thus preventing any possibility of accidental displacement. The spiral spring *a* is interposed between the head of the bolt and the jaw, thus keeping the head steadily in contact with the end of the spring, and preventing any rattle that might otherwise occur in those parts. The invention is peculiarly adapted to persons who frequently change or remove their shafts or tongues—the only effort required being to depress the spring and remove the bolt, no tool whatever being needed for the purpose.

ERRATUM.

A typographical error occurs in the next to the last line of p. 384 of the *Journal* for June (vol. xlv.), which alters entirely the meaning of the sentence. The word "only" should be omitted. The intention was to state that Newton founded his assertion, on a mathematical demonstration, and not on failures to solve the problem referred to. ED.

A Comparison of some of the Meteorological Phenomena of MAY, 1863, *with those of* MAY, 1862, *and of the same month for* TWELVE *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By JAMES A. KIRKPATRICK, A. M.

	May, 1863.	May, 1862.	May, 12 years.
Thermometer—Highest—degree, .	90·00°	85·00°	90·00°
" " date .	23d.	23d.	7, '60; 23, '63.
" Warmest day—Mean,	79·83	75·80	79·83
" " " date,	23d.	23d.	23d, 1863.
" Lowest—degree, .	40·00	40·00	35·00
" " date, . .	7th.	8th.	7th, 1854.
" Coldest day—Mean,	42·50	50·50	40·00
" " " date, .	6th.	1st.	3d, 1861.
" Mean daily oscillation,	19·15	19·81	17·29
" " " range, .	5·43	5·77	5·54
" Means at 7 A. M., .	59·32	57·85	58·24
" " 2 P. M., .	71·76	70·08	69·64
" " 9 P. M., .	62·64	61·32	61·28
" " for the month,	64·57	63·08	63·05
Barometer—Highest—Inches, .	29·975 in.	30·058 in.	30·338 in.
" " date, . .	21st.	12th.	4th, 1852.
" Greatest mean daily press.	29·962	30·007	30·273
" " date, . .	21st.	12th.	5th, 1852.
" Lowest—Inches, .	29·295	29·518	29·096
" " date, . .	31st.	19th.	27th, 1861.
" Least mean daily press.,	29·343	29·553	29·243
" " date, . .	31st.	19th.	27th, 1861.
" Mean daily range, .	0·085	0·124	0·121
" Means at 7 A. M., .	29·783	29.785	29·824
" " 2 P. M., .	29·736	29·740	29·787
" " 9 P. M., .	29·769	29·760	29·811
" " for the month,	29·763	29·762	29·807
Force of Vapor—Greatest—Inches,	0·700 in.	0·594 in.	0·771 in.
" " " date, .	30th.	21st.	14th, 1854.
" " Least—Inches, .	·189	·105	·069
" " " date, .	5th.	8th.	2d, 1861.
" " Means at 7 A. M.,	·375	·320	·352
" " " 2 P. M.,	·365	·324	·368
" " " 9 P. M.,	·406	·335	·374
" " " for the month,	·382	·326	·365
Relative Humidity—Greatest—per ct.,	91 per ct.	93 per ct.	100 per ct.
" " " date,	7th.	1st and 27th.	Often.
" " Least—per ct.,	28.	18.	16
" " " date,	22d.	8th.	5th, 1855.
" " Means at 7 A.M.,	72·3	64·2	71·2
" " " 2 P.M.,	48·3	44·9	50·9
" " " 9 P.M.,	69·8	60·3	68·1
" " " for the month	63·5	56·5	63·4
Clouds—Number of clear days,* .	15	9	10·7
" " cloudy days, .	16	22	20·3
" Means of sky cov'd at 7 A.M.	51·0 per ct.	60 per ct.	57·9 per ct.
" " " " 2 P.M.	55·5	60·3	59·6
" " " " 9 P.M.	38·1	41·0	45·5
" " " for the month,	48·2	53·7	54·3
Rain—Amount, ...	4·792 in.	2·083 in.	4·240 in.
No. of days on which Rain fell, .	11	9	12·8
Prevailing Winds, ...	N77°0′ W·077	N53°37′W·136	N70°4′ W·113

* Less than one-third covered at the hours of observation.